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Mining Gold by Proxy

The Old-Fashioned Miner Replaced by Machinery

By Arthur L. Dahl

MANY men have won fortunes by grub-staking some prospector who had faith enough in his "hunch" to go off alone into the silent desert in search of the yellow gold of commerce. Many other people have made fortunes by grub-staking a modern mechanical miner, soulless, brainless, and yet more tireless, more powerful, more efficient and more honest than any human prospector.

Out in California the old-fashioned miner, with his pick, his frying pan and his pipe, has been relegated to the discard. He has been succeeded by a steel monster which digs in one minute more earth than the huskiest '49er could have uncovered in a day, and this unseeing miner—the modern gold dredge—discovers more gold in the waste river washes than the most eagle-eyed prospector could along the mother lode. In fact, the dredge can produce sufficient gold to pay tidy dividends from land which the human miner would pass over in disgust.

The dredger process is a splendid way to mine by proxy. The latest model gold ship is a mighty expensive pick—a big one costs a third of a million dollars. But in these days of universal incorporation, it is easy for one to possess an intangible, indivisible part of a third-of-a-million-dollar dredge, as evidenced by a beautifully engraved stock certificate. And so, the lawyer, the baker, the candlestick maker, can each grub-stake one of these huge artificial miners, and go to sleep at night to dream of that tireless machine plowing through cobblestones and boulders in search of the grains of gold needed to pay the dividends promised by the engraved stock certificates.

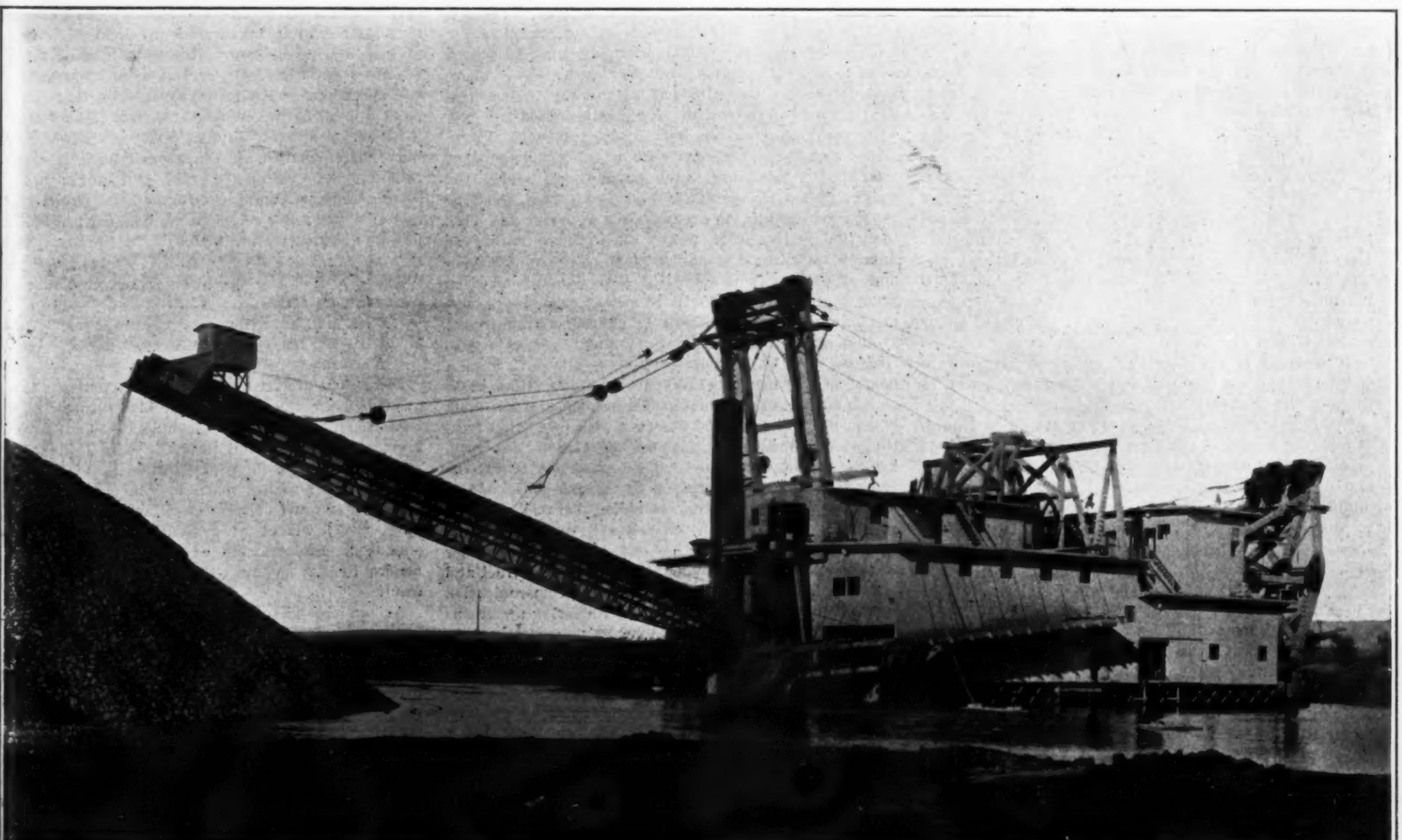
A gold dredge is a very methodical, careful, dependable miner, even if it can't think. It doesn't insist upon observing union hours, for it works night and day, and never goes to Sunday school. It has a prodigious appetite, and digests its food so well that on regular "clean-up" days there is usually to be found in its sluice boxes enough shining metal to make a gold brick of a size and quality that would dazzle the expert assayer as easily as it would the most unsophisticated rube.

The operation of a modern gold dredge is very interesting. To begin with, like ivory soap, "it floats." All of the machinery is mounted on a flat, scow-like hull, which permits the dredge to be floated to any part of the inclosed pond in which it operates. As the endless chain of buckets eat into the bank, the dredge advances ("stepping forward" as the dredge men say) until a path the width of the boat has been dredged up and the contents of the ground passed through the alimentary canal of the ship. When the boundary of the dredging area is reached, the boat is turned, and works back the other way.

The digging end of a dredge is composed of an endless chain of sixty or more buckets, each weighing about two tons. One of these buckets will hold thirteen and one half cubic feet of earth. These buckets are mounted on a digging ladder which is so constructed that it can be raised, lowered or moved from side to side at will. Some dredges can dig to a depth of thirty-five feet, or more. The "lips" or edges of the digging buckets are sharp enough to cut through the earth, and as the dredge "bucks" the bank, the buckets revolve on their endless belt, and are filled to overflowing as they resistlessly eat their way through the soil and cobblestones in their path. When the buckets reach the top of the digging ladder, they turn and dump their load of gold-bearing gravel into a cylinder which conveys the material to an immense revolving drum extending the whole length of the boat. As the gravel is dumped from the buckets it passes through numerous streams of water, under terrific pressure, which disintegrates the mass of earth, breaking up the lumps and setting free the tiny particles of gold that are imbedded in the sticky clay.

From the receiving cylinder, the material is conveyed to the revolving drum, where it is again subjected to numerous streams of water, under heavy pressure. This drum is perforated throughout its entire length with tiny holes. It is also constructed at such an angle that one end is much lower than the other. As the mass of water-soaked soil and stones tumbles and churns in this revolving drum, the larger stones are carried by gravity to the lower end and are tossed onto an endless belt which conveys them, by way of the stacker, to the tailings pile at the rear of the boat. The finer particles of sand and soil, including the gold, are carried by the flow of water through the small holes in the drum, and are deposited upon a series of

(Continued on page 324.)



The Largest Gold Dredge in the World.

MINING GOLD BY MACHINERY.

Report on the Condition of Aeronautics in Germany

Extracts from a Report by the American Consul-General, Berlin, April 4th, 1913

THE industry of aeroplane manufacture comprises more than a dozen aeroplane factories with an aggregate capital of about $360,000 (as compared with about twenty factories in France, six in England and five in Austria), as well as several special factories for aeronautical motors and three or four substantial plants for the manufacture of airships.

AERONAUTICAL MOTORS.

In January last a contest was held under official auspices to determine the relative merits of the various German aeroplane motors.

The conditions and tests were designed to determine the all-round efficiency of the competing motors. The chief prize, that offered by the Emperor, was awarded to a 4-cylinder 100 horse-power motor entered by Benz & Co. of Manheim. The other prizes fell as follows:

Imperial Chancellor's prize to 6-cylinder 80 horse-power Daimler (Mercedes) motor, new type with steel cylinders.

War Minister's prize to 4-cylinder 100 horse-power, N. A. G. (*Neue Automobil-Gesellschaft*) motor.

Navy Department's prize to 4-cylinder Daimler (Mercedes).

Interior Department's prize to 4-cylinder 100 horse-power Argus motor.

In all nineteen motors completed the test.

The ranking given above does not appear to have given entire satisfaction in aeronautical circles. The weight of opinion seems to incline in favor of the Mercedes or Daimler as the most efficient and reliable aeroplane motor. A German aeronautical engineer writes me on this subject:

"The best and most reliable German aeronautical motor, which has proved itself the most efficient for practical purposes, is certainly the Mercedes (the German Daimler). The advantages of these motors is their reliability. During a test of a new type the motor ran more than fifty hours uninterruptedly and without trouble. The shape adopted for this motor is such that it may be conveniently built into an aeroplane. An especially desirable form of construction is that with hanging cylinders and underset propeller shaft. Owing to the pendant position of the cylinders the center of gravity is more favorably placed and the outlook from the machine is freer. The undersetting of the propeller shaft is advantageous in that the best economical working of the propeller occurs at about 800 revolutions per minute, while for the motor it is best when the motor shaft operates at a higher speed. In the present case the motor shaft makes about 1,600, while the propeller makes 800 revolutions per minute, and both elements thus operate at their greatest efficiency. The benzine and oil consumption of Mercedes motors is extremely low.

"I would name the Benz as the second best motor. It has very high cylinders, and as a result runs rather jerkily. The Benz firm has up to the present manufacturer only one type, 4 cylinders, 130 millimeters (5.12 inches) bore, 180 millimeters (7.09 inches) piston stroke, developing 100 horse-power at 1,250-1,300 revolutions per minute. The motor has not yet been tested out in a flying machine, but at the recent motor contest it took first prize.

"The Argus is a widely used aeronautical motor in Germany, but its qualities fall a long way short of those of the Mercedes.

"As fourth best the N. A. G. motor should be named. It took third prize at the recent tests for the Emperor's prize. It is a somewhat altered type of Wright motor and develops 95 horse-power at 1,350 revolutions per minute. In practice frequent complaints are heard as to the leakiness of the radiator, which is made of sheet copper instead of cast-iron or steel as in the case of most motors.

"I wish to point out as of no small importance that the French Gnome motor must be demounted every eight working hours in order that the soot and oil may be cleaned out. This is certainly a great disadvantage from the military point of view. It is accordingly my opinion that, while the Gnome is very well suited for racing and sport, for practical traffic the water-cooled motor will always remain the better."

A 60 to 70 horse-power, 4-cylinder motor is one of the latest productions of the Daimler works, and is regarded by experts as one of the best in Germany. The propeller makes from 700 to 800 revolutions per minute to the motor's 1,400 to 1,600 revolutions per minute. This motor won the Navy Department's prize in the recent Emperor's motor prize contest. The Imperial Chancellor's prize in the same contest was won by the 75 to 85 horse-power, 6-cylinder motor.

AEROPLANES.

As to German aeroplanes, the first distinction is between monoplanes and biplanes. The biplanes are constructed in this country partly in accordance with the Wright system with warping beams and in part with ailerons after the style of the French Farman construction. In both these systems the propellers work behind the planes and the motor is mounted behind or near the pilot and the passenger. The mounting of the motor behind the crew has proved to be dangerous, as in case the machine falls, the motor is very apt to crush the occupants. Recently motor and propeller have been mounted forward of the planes, even in the case of biplanes. As between monoplanes and biplanes, the army administration is said to consider that the biplane does not offer special advantages sufficient to offset the higher cost of its construction and in general the single-plane type appears to enjoy the preference at present, but the biplane, which fell behind the monoplane in 1911, has again won more recognition.

The Aeronautical Department of the German army has promulgated standard specifications applicable to all aeroplanes purchased during 1913 for military purposes. In substance they are as follows:

"German materials and products must be exclusively employed in the construction of the aeroplanes. They must be insusceptible to weather influences and all parts must be easily interchangeable. They must be so built as to be readily assembled and demounted into sections which can be easily loaded on railway cars or road vehicles. Assembling must not take more than two hours nor demounting more than one hour, nor require the asistance of more than 5 persons. With a view to transportation the greatest width must not exceed 14.5 meters (47.6 feet); the length over all, 12 meters (39.4 feet); and the height, 3.5 meters (11.5 feet). Motors of more than 100 horse-power are not to be used except with the special approval of the military authorities. Other things being equal, preference will be given to machines equipped with low-powered motors. It must be possible to start the motor from the pilot's seat. A positive speed of at least 90 kilometers (56 miles) an hour is required. Moreover, it must be possible in every case to reduce the speed during a flight to 75 kilometers (46.6 miles) and still fly forward on a horizontal line. Provision must be made for carrying fuel, oil, etc., sufficient for four hours' running. The fuel supply must be placed so as to afford absolutely no danger to the crew. There must be some device provided for thoroughly suppressing the noise of the motor. A machine loaded not only with fuel, oil, etc., for four hours and with instruments and tools, but also with a further load of at least 200 kilogrammes (441 pounds), in which the weight of the pilot and observer is included, must be capable of leaving the ground after a run of not more than 100 meters (328 feet); of attaining within 15 minutes an altitude of at least 800 meters (2,625 feet) and of coming to a standstill after landing on even ground within a distance of 70 meters (230 feet). The machine must also be capable of rising from rough ground and landing thereon. It must further be possible to land by gliding with motor shut off from a height of 500 meters (1,640 feet) making either right or left-hand curves. Comfortable accommodations must be provided for pilot and observer with protection from the wind. The carosserie must afford sufficient room for the installation of a bomb-throwing device, for the storing of bombs and for photographing without hindrance. The instruments, including barometer, barograph, compass, tachometer and stop-watch, must be arranged so as to be readily observable. It must further be possible for the pilot to watch the stand of fuel and oil while in flight. There must be easy communication between him and the observer. The steering apparatus must work as easily as possible. Automatic stability is a great desideratum."

The German machines are somewhat heavier than the French. They are, however, noticeably more durable. A well-built steel monoplane equipped with a 70 to 80 horse-power motor weighs when empty about 475 kilos (1,047 pounds), and equipped with a 100 horse-power motor, about 550 kilos (1,213 pounds). The price of a good German monoplane with a 100 horse-power Mercedes motor is about M. 25,000 ($5,950); equiped with a 85 horse-power motor, about M. 21,000 ($4,908); and with a 70 horse-power motor, about M. 19,000 ($4,522). The prices for biplanes are from M. 4,000 to M. 5,000 ($952 to $1,190) per machine higher. Cheaper machines are not to be recommended for military purposes as they are not generally equipped with good motors.

HYDRO-AEROPLANES.

We have not yet obtained any noteworthy success in Germany with hydroplanes and hydro-aeroplanes.

The Albatros Company writes that the Albatros biplane, type M Z, is provided with an automatic motor starter, benzine cleaner, benzine control dial, double steering gear and all necessary instruments with replace parts and tools for both motor and machine. The biplane is equipped according to specification with 100 horse-power Argus, N. A. G. or Mercedes motors. This type has won the more important long-distance flights of recent years. The company refers to the various cross-country flights of the Prussian officers of the Aeronautical division, to the victory of Bruno Konig in the tour through Germany and to the victory of Lartsch in the round-trip through Saxony. This biplane has been recently equipped with gear for travel on land and water. In the Heiligendamm meet of the "Deutche Fliegerbund" the Albatros machine came off best. As the conditions were, however, so stringent that aeroplanes in their present development could not fulfill them, the German Navy Department considered itself authorized to hold another meet, which took place in Putzig, the latter part of October last. The Albatros biplane, type M Z, won this contest, and the German naval authorities have, therefore, purchased the biplane and ordered several others which have been delivered and accepted. Albatros biplane, type D E, is an example of a new development which combines the stability of the biplane with the speed of the monoplane. The machine is built after the fashion of a monoplane. The body proper is boat shaped. It is exceedingly staunch. In the last Prussian military maneuvers this machine came off brilliantly. The Albatros company not only supplies aeroplanes for the Prussian army and the German navy, but also to the governments of Russia and Bulgaria.

With reference to the manufacture of his aeroplane, J. Doedecker lays stress on the fact that all parts are easily detachable. Planes, ground running gear and rudder, being the most important parts, are made of steel. The result is that the machine can be readily taken apart, and the material is but little affected by weather conditions. Mr. Goedecker also wishes to draw special attention to the excellence of the ground running gear. In a number of overland flights it has always been possible for aviators to land on fields and meadows and thence to ascend again. Capsizing has never occurred. He mentions further that his aeroplanes may be accounted the most stable and the most easily steered, so that amateurs after three or four trials running on the ground have become self-reliant flyers. He quotes prices at factory: One complete aeroplane, equipped with 70 horse-power Daimler motor, $3,450; one complete aeroplane with 100 horse-power Daimler motor, $4,165; and promises delivery in 8 weeks.

The prices of the two-seated Rumpler Taube monoplane are as follows:

With 100 horse-power Argus motor ..	$5,557
With 100 horse-power Mercedes motor	6,355
With 125 horse-power Argus motor ..	6,069

The prices are free on board Johannisthal, the flying grounds near Berlin; payment one third with order, balance on delivery, the machine to be all assembled and ready for use and tested in actual flight. With reference to shipment to the United States, the following specifications are made by the company; packing ready for sea and delivery cost, including freight, Hamburg, $286; weight of box, about 2,600 kilos (5,732 pounds); measurements of box, 10.5 meters by 2.7 meters by 3.2 meters (34.5 feet by 8.8 feet by 10.5 feet).

Among the victories which the Rumpler machines have attained are the first reliability flight on the Upper Rhine, the Kiel Aviation Week, the Katherine prize (Berlin-Munich), German Circuit Flight, Schwabian Circuit Flight, Second Reliability Trials on the Upper Rhine, 1912; Berlin-Vienna Flight, June, 1912; and South German Circuit Flight, 1912. The Rumpler-Taube also met with brilliant success at the recent Imperial maneuvers and at the maneuvers at Thorn. Up to the present about 100 machines have been delivered to the German military authorities. The company says it receives orders every quarter, the order for the last quarter being for 25 machines. Special stress is laid upon automatic stability, easy piloting and facility of operation.

The Rumpler Company also manufactures hydro-aero-

planes, of which several are in service at Putzig near Danzig. One was recently sold to the Norwegian government and is at the present time stationed in Horton, Norway.

DIRIGIBLE AIRSHIPS.

The best known German dirigible airships are the Zeppelin, Schutte-Lanz, Parseval, Siemens-Schuckert and Gross. These five types differ markedly from each other in construction. The two first named, Zeppelin and Schutte-Lanz, have rigid balloon bodies. Zeppelin uses aluminium and Schutte-Lanz wood for the material of the frame. Both types of construction have so far proved good, but it may be that the Zeppelin is the better. The Zeppelin has often remained very long aloft in test flights; thus, a short time ago it accomplished a 36-hour voyage without any accident or stop whatsoever. These ships are built so that they can land on water and they are, therefore, purchased by our naval administration. The motors are very reliable and are manufactured by a sister company of the Zeppelin shipbuilding concern (Maybach motors). Herr Maybach was formerly an engineer with the Daimler (Mercedes) Motor Company. The Daimler Motor Company, besides Maybach, makes airship motors. They are of 100 horse-power and 200 horse-power. The products are of about equal value, but it may be that Maybach has had the greater experience with airship motors. The other German airship motors cannot be counted as first-class.

The rigid ships maneuver very well in the air, but good hangars are necessary. Turntable hangars are the best. There is one in Germany. The long trips made by the rigid type are made possible principally by the minimal gas loss which characterizes this system. In the rigid ships the gas is not contained at large in the balloon body, but in ballonettes which are confined within the main balloon body. The ballonettes are very impervious to gas. Recently they have been made out of gold beater's skin (gold beater's skin is the outer skin of the blind gut of the beef). The ballonettes are furthermore surrounded by the air inside the balloon body and by the balloon covering itself, which hinder the invasion of the sun's rays. It is a great advantage of the rigid type that the outer shape of the body cannot be altered by temperature changes. The chief difference between the Schutte-Lanz and the Zeppelin airship lies in the material of which they are built and in the outer shape. Neither factory takes orders for export.

The Parseval dirigibles are the most widely used in Germany. They have the great advantage over the rigid types, that they can be emptied anywhere and packed for transportation. The Parseval patents have been purchased by the Luftfahrzueg-Gessellschaft m. b. h. in Bitterfeld, and orders for export are taken by the company.

The Siemens-Schuckert airship is of very large dimensions and possesses a high load-carrying power. It differs from the Parseval ship only in the details of construction. A half-rigid dirigible exclusively for military use is manufactured by Major Gross, but it has been supplanted by the types mentioned above.

The speed of a Zeppelin airship equipped with a 500 horse-power engine reaches some 70 kilometers (43.5 miles) an hour. A Zeppelin can carry more than thirty persons.

The Increased Cost of Warships

The correspondence which has taken place between the First Lord of the British Admiralty and the Prime Minister of the Dominion of Canada, incidentally indicates the great advance that has taken place within recent years in the cost of ships. The main theme of the letters is concerned primarily with the possibility of building warships in the Dominion, and Mr. Churchill enumerates the very extensive and costly appliances necessary for manufacturing all the elements which go to make up a modern battleship. He arrives at the conclusion that the cost of laying down the plant alone would, at a rough estimate, be approximately $75,000,000, and that four years would be occupied in the process. He indicates that the new shipyard which Sir W. G. Armstrong, Whitworth & Co. have constructed below the swing-bridge on the Tyne, in order to enable them to build ships of greater beam, has cost approximately $3,750,000, and that two years have been occupied in its preparation. It is further stated that the Japanese have taken twenty years to work up their warship building, and now take over three years to build a battleship; although anxious to build all ships in their own country, they still find it necessary to have some of them built in Great Britain. The figures given by Mr. Churchill show that a battle-cruiser of the "Australia" type, ordered in Great Britain in 1909-10, would cost, according to the prices then current, $11,468,300, whereas to-day the price would be $13,260,500. Again, the cost of three "Town" cruisers has gone up from $5,561,550 to $6,174,-500; six torpedo-boat destroyers from $3,335,575 to $4,215,000; three submarines from $1,374,375 to $1,825,-000; and stores and fuel for these from $296,400 to $322,000. Mr. Churchill takes the view that the facts prove that it is impracticable to proceed with the building of capital ships in Canada at the present time. He does not attempt to give in actual figures the cost now of the ships to form a Canadian fleet unit corresponding to that of Australia, but he adds that the increase in cost for ships built in Canada would amount to 25 or 30 per cent over the present prices quoted in Great Britain. The interesting point is that now Canada, for such a fleet unit as Australia has built, would have to pay, even in Britain, $25,797,000, instead of $22,035,755 three years ago, as compared with seven millions for three battleships of the latest type. The First Lord points to the higher cost of maintaining these ships in Canada, owing to the economic conditions prevailing there, and estimates that, at Canadian rates, the cost of maintenance would be $2,906,250 per annum, against $2,060,960 under prevailing conditions here. On the whole question of manning Mr. Churchill points out that our resources are now strained to their utmost limits, more especially as regards lieutenants, specialist officers (gunnery, torpedo, and navigation), and the numerous skilled professional ratings which cannot be improvised or obtained except by years of careful training. His arguments undoubtedly force one to the conclusion that the most practical and economic course for Canada to pursue—at the present time, at all events—is to make a contribution in ships, leaving the manning and other provisions to the Imperial authorities. But, of course, the home country cannot dictate to any of the Dominions over the seas the policy they should pursue in this matter.—*Engineering.*

Human and Other Population of the United States

It is interesting to compare with the total human population the total heads of cattle and other domestic animals which we find it necessary to maintain to furnish us with our supplies for domestic consumption and for export. According to the Abstract of the Thirteenth Census of the United States (1910) the human population amounted to 91,972,266 souls. The total number of cattle on farms was about two thirds of this, 61,803,866. Of these 20,625,432 were cows kept for milk; 12,023,682 were cows not kept for milk. The number of horses was 19,833,113. Pigs numbered 58,-185,676. There were 52,447,861 sheep, and about three million goats.

Floral Blue*

By P. Q. Keegan

The origin of a coloring matter is technically termed chromogen, i. e., the precursor thereof, or the special chemical constituent, whose presence in the corolla is necessary for its production. Most vegetable colorations are derivatives of what is called the aromatic series of organic bodies, and it is known that as certain members of this series produce the magnificent aniline dyes, whose spectacular effects are familiar in theaters, and so on, so also other members of the same series form the origin of the beautiful tints and hues which clothe the flowers of the field and garden. The floral structures (corolla, sepal, and so on) are built up out of a number of chemical constituents, e. g., cellulose, wax, oil, tannin, mucilage, salts, and so on, which may be withdrawn therefrom and separated by chemical methods. The question arises, a most interesting one to the inquiring mind, what is the particular component of this structure to which is due the outcome of that most enchanting adornment, the blue, red, or yellow floral coloration? We must, by diligent analysis and with inexhaustible patience, turn over every clue; we must test and examine all the constituents, until we find some particular one which unquestionably betrays its relationship to the aromatic series of hydrocarbons aforesaid; for we are assured that therein will lie the true spring and fountain of all this floral glory.

We commence the research naturally by studying specimens of plants which bear really true blue flowers, taking care, of course, that we do not mistake a violet or purple corolla for a really blue one. An astute chemist, who is well versed in the analysis of tannic materials, can foretell where such a subject is sure to be found. He knows that such and such orders of plants, for instance, the Rosaceae or the Leguminosae, do not produce blue flowers, and he can assign a reason therefor. On the other hand, he is quite convinced that certain other orders, such as the Campanulaceae or the Gentianaceae, can assuredly do so, inasmuch as that particular constituent called tannin is of a similar kind in each of the latter two orders, but is widely different from that in either of the two former orders. Which is as much as to say, that a kind of chromogen exists in roses and sweet peas which does not exist in gentians or bell flowers, and *vice versa*. True blues exist in veronicas, salvias, verbenas, basil, solanum, penstemon, nemophila, convolvulus, borage, hound's tongue, and in all the orders allied to Gentianaceae and Compositae; but not in lupins, vetches, peas, vetchlings, geraniums, hollyhocks, primulas, balsams, flax, and so on. In the blue flowers just mentioned there is a chromogen, i. e., a tannin common to all as detected by chemical analysis, whereas in the non-blues this special substance does not occur. A noteworthy fact or peculiarity is that while one series or order of plants containing this special color-producing body may exhibit red or blue flowers only in certain species or even in one and the same plant, another series or species with the same chromogen evolves nothing but red or yellow adornments. In fact, in some cases, as, for instance, in begonias, a genus may be quite capable of displaying an azure appanage, but its powers are confined to that of red.

However, to come to details, it may be mentioned that the parent substance of the blue flower is called caffetannin and is imbibed in every cup of coffee we drink, whereas when we drink tea we merely absorb something concerned in the production of red camellias for example. The chemist will inform you that caffetannin exists in somewhat different forms, and has a different composition, perhaps, in different plants. Some say it is a glucoside; others deny that; and some others again assert that it is a mere mixture of organic acids and other substances. What is beyond question is that it contains in its composition (molecule) more of what are called hydroxyl groups than perhaps any other tannic compound known; that is to say, that where an atom of hydrogen might be found, an atom of oxygen takes its place. Oxygen is an element essential to the support of animal life, but it is also a supporter of coloration, yellow for less of it and blue for more of it. Moreover, we can artificially produce a blue compound from caffetannin; but from any other kind of tannin save one, this cannot be done. We have only to leave a solution of caffetannin freely exposed to the air with a little chalk added, when we see the latter gradually turn green, and then on pouring off the liquid and adding some acid, a red solution is obtained very like the tint of the foxglove corolla, and so on, and which, like it also, may by a certain treatment be changed into a brilliant blue. By a careful application of dilute solutions of an iron and a sodium salt the dilute colorless solution of the same tannin can be induced to yield a beautiful and persistent azure liquid.

In fact, the complete analysis of any plant that contains this tannin reveals in many ways that we are dealing with a powerful color-evolving substance. Then, again, we observe similar phenomena repeated when other plants, perhaps belonging to widely different classes or orders, are taken in hand. But however wide these taxonomic differences, we find invariably one common feature, viz., the capacity to produce a true blue flower. Moreover, this most remarkable feature is absolutely independent of the status of the organism, of the organic perfection or degradation of the species. The gentians, for instance, with their feeble powers of assimilation and their mycorrhiza infestation; the Compositae deprived of one at least of the chief factors of organic perfection; the Labiates more perfectioned than the borages or the solanums; the Ranunculaceae, Liliaceae, and so on, with types representative of a special kind of organic debasement, all these and more rise to the same high level of floral glory when they unfold and hang out to sun and shower the "soft eye-music" of the flaunting blue.

In fact, the blue corolla is caused by the comparative strength and completeness of the process of de-assimilation occurring there, and this, no doubt, is also the cause why in some plants a certain kind of tannic chromogen is produced, and not so in others. The protoplasm, in order to eliminate from its molecule a tannin containing six HO groups, would de-assimilate or oxygenize more completely than if it produced a tannin with only four or five HO groups. Also, in Gentianaceae with very numerous ovules, blue flowers of the most brilliant description are frequently exhibited; in Compositae with only one ovule they are comparatively rare and never so effective. In the latter case, the de-assimilation is not complete, various volatile oils, resins, and tannoids being a common outcome of the process. It may occur, of course, that the plant itself may produce in its green organs a large quantity of caffetannin, for example, the common yarrow, while the flowers are white or pale pink; but this apparently does not occur in plants with vigorous powers of reproduction (e. g., gentians) wherein tannoids only appear in stem, leaf, and root, the more complete and final products being found exclusively in the floral parts. Therefore, in accordance with this report herein set forth, let gardeners cease from troubling to "evolute" a pure blue flower on a plant incapable of constructing a tannic chromogen containing less than a certain number of hydroxyl groups.

* Reproduced from *Knowledge.*

Two "Stackers" of Gold Dredges at Work Dumping Tailings.

View of Dredged Lands on the Yuba River, California.

Mining Gold by Proxy

(Continued from first page.)

gently elevated riffles, or gold plates, one emptying into another, in a manner to reduce the speed of the flowing water. Along the riffles are quantities of quicksilver, which attract and hold the gold, allowing the lighter soil to be carried away by the water. The gold amalgamates with the quicksilver, and is easily retained until the "clean-up" crew comes around on its weekly visit. The amalgam is then retorted, thus separating the gold from the quicksilver, and the latter is returned to the riffles to again affinitize with the unsuspecting gold.

A gold dredge is compelled to live a hard life, and must be made of very stern stuff indeed. None but the best material can go into the construction of a good gold ship, and some of the larger ones weigh as much as 2,000,000 pounds. The hardest Bessemer steel is required for the digging buckets, for the ordinary steel of commerce would be worn to a shadow in a few months, if subjected to the terrible grind of eating a path through almost solid masses of granite cobblestones. Even with the use of the hardest steel known to science, the life of these digging buckets is comparatively short—about two years.

Gold dredging in the United States is practically confined to three principal districts in the Sacramento Valley, in California. One is along the Feather River, near Oroville; the second, along the Yuba River, near Marysville, and the third near Sacramento. There are about sixty-five dredges in the California field, the majority of which are controlled by companies operated by W. P. Hammon, who built the first successful gold dredge in the United States. The annual output from the California dredges is about seven million dollars. A number of small gold dredges are successfully operated in Alaska, and one is being operated in Idaho. Gold dredging has been one of the great industries of New Zealand for many years, and the dredging field has, in recent years, gradually extended to all parts of the world. A group of American and English capitalists are investing over a million dollars in a dredging proposition in Colombia, South America, and dredges are being built at Marysville, California, for operation in South Africa and in Siberia.

Pork Production*

By J. I. Thompson

California is producing only one hog for every three people in the State. She is consuming more than three times that many. Approximately forty carloads of pork products, chiefly hams, bacon and lard, and twenty-five cars of live hogs are shipped here from other States every week to supply the demand. Not only do we need more hogs to supply the market demand, but at the rate dairying is increasing more hogs are needed to consume the by-products from these dairies.

Ours is a meat consuming people and always will be. The hog is in a list all by himself as an economical producer of edible material. From one hundred pounds of dry matter a sheep will produce about 2.6 pounds of edible meat and a steer 2.8 pounds, while a hog from this same amount of feed will produce 15.6 pounds of meat suitable for human food.

The hog differs from other classes of stock in his physical make up and his ability to handle bulky food. The capacity of his stomach is only about 65 per cent of that of the sheep, or for one hundred pounds of live weight only about 33 per cent as much, while compared with a cow his stomach capacity is only 8 per cent. These figures readily indicate that the feed for the hog must be much more concentrated than that of the sheep and cow.

Interior View of Dredge, Showing Dynamos.

Interior of Revolving Drum Which Separates Gold from the Soil.

The markets here desire a hog of about two hundred and twenty-five pounds live weight and will pay a relatively higher price for hogs properly fed than for those improperly produced, provided they are of the type and finish that will dress out a large per cent of desirable cuts.

The younger the pig the more economical his gains, so it pays to get him up to market weight in the shortest possible time. The reports of various experiment stations show that pigs under fifty pounds gain weekly 16 per cent of their body weight, pigs under one hundred pounds 7.4 per cent, under two hundred pounds 5 per cent and under three hundred pounds only 3.8 per cent. Also that a fifty-pound pig uses only 18 per cent of his feed for maintenance, leaving 82 per cent for gains. A one hundred pound pig has left for gains 75 per cent, and a two hundred pound pig only 64 per cent of the feed that he consumes.

The smaller pig eats more for his size than the larger one and requires less for maintenance. Therefore, the only conclusion is that it pays to push them along rapidly.

If a pig were made to weigh two hundred and twenty-five pounds at eight months of age, he would have consumed for maintenance alone approximately two hundred seventy-five pounds of food of the equivalent of wheat middlings. If he did not reach the same weight until fourteen months of age, he would have consumed for maintenance alone approximately forty hundred and eighty pounds of food the equivalent of wheat middlings.

The amount digested over and above that used for maintenance represents the amount available for gains. Therefore, the pig that eats the most, provided he makes the proper use of it, is the most economical.

There are three breeds of lard hogs and two of bacon hogs generally distributed throughout this State and all of them seem to fit quite well into the environment. The lard breeds are Berkshire, Duroc-Jersey and Poland-China; the bacon breeds, Tamworths and Yorkshires. Breeders ordinarily succeed best with the breed they like best. Any breed will undoubtedly give more uniform results than a mixture of two or more breeds.

In the selection of sows for the breeding herd particular attention should be paid to conformation, constitution and breediness or feminity. Choose those showing superior depth, width and uniformity, with length in proportion. Insist on a deep, broad chest with no perceptible drop back of the shoulders, with enough bone to carry the weight readily and sufficient quality to give an attractive appearance. Old sows produce larger, stronger pigs, and more of them than young sows, so they should not be sold so long as they breed regularly and are not too fat, heavy or deaf to make good mothers.

Six strong, vigorous pigs to the litter are more desirable than eight or nine inferior ones. Whether the number is large or small they should be kept growing rapidly until they are ready for market.

There is no more desirable feed for hogs of any age than alfalfa pasture, and the fact that it is available here for about nine months of the year is a most important item. As a single feed, it is not sufficient for growing or fattening hogs, but should be supplemented from a list of concentrates, among which are barley, corn, wheat, shorts, middlings, bran, oil meal, soy-bean meal, tankage, skim milk, beets, and pumpkins.

* Circular No. 96 of the Agricultural Experiment Station, University of California.

The Pendulum Propeller Rudder*

An Oscillating Substitute for the Screw

By H. C. Vogt, M.F., C.E.

ELEVEN years ago a Danish firm of shipbuilders built a 23-knot cruiser for the Russian government and the officers' launch for that cruiser was furnished with a pendulum propeller, an original propelling device, which functions after the manner of a fish's tail. This launch had a displacement of 4.3 tons, and attained a speed of 7.7 knots at 12 effective horse-power, and possessed unrivaled maneuvering power. The pendulum propeller rudder was 3 feet long, with an area of 1.2 square feet, and weighed 40 pounds; each swing was 72 degrees (36 degrees to each side of the vertical); 180 double swings or oscillations per minute of this pendulum propeller rudder gave 7.7 knots, and its corresponding angular velocity became 7.5 radius per second and the speed of its tip 22.5 feet per second. There being only one unbalanced pendulum propeller rudder, the after end of the launch made, of course, 180 diminutive vibrations per minute, which would have been avoided with two symmetrical pendulum propeller rudders. The vibrations had not, at 180 double swings, the same disagreeable character as when the number of double swings was increased to 230 per minute and the tip speed to 29 feet per second (by reduction of the pitch, explained later on), the speed being at the same time reduced to 7.4 knots; in this last case the centrifugal force, when the pendulum propeller rudder passes the vertical, amounts to 159 pounds, whereas at 180 double swings per minute it only amounts to 97 pounds, or $\frac{1}{99}$ part of the weight of the launch. At 160 double swings per minute, corresponding to about 7 knots, the vibrations had no disagreeable character at all, and the maximum centrifugal force of the pendulum propeller rudder now amounted to 77 pounds, or $\frac{1}{125}$ part of the launch's weight.[1] The reaction against this centrifugal force depends on the resisting areas, therefore, a ship having 9 times greater dimensions than the launch or of $4.3 \times 9^3 = 3{,}135$ tons would withstand a corresponding centrifugal force of $77 \times 9^3 = 6{,}237$ pounds, or about $\frac{1}{1000}$ part of the weight of the ship; and similarly a schooner of 200 tons would withstand a corresponding force of 1,000 pounds, being about $\frac{1}{400}$ part of the weight of the schooner.

When high speed is required, it is obtained by increasing the pitch of the pendulum propeller rudder, not the number of its oscillations. In whales and big birds a very high pitch is used, together with a very great area, thus the vertical speed of the oscillating center of effort of a big bird's wing is only 5 to 7 feet per second, while the forward speed is 10 times greater, and as the quickest torpedo boat is surpassed by the dolphin its speed must be 30 to 35 knots or 50 to 60 feet per second; the speed of the enormous finwhale is estimated at 80 to 90 feet per second. The pendulum propeller rudder is admirably adapted for high speeds, but it is not able to utilize sufficient power to drive a ship at high speed, and it must, therefore, in such cases, work together with the screw propeller. If a ship of 3,000 tons should have the same driving area in proportion to its resistance as a finwhale, then its propeller would be 50 to 60 feet in diameter with a pitch of 20.

Since the above experiments others have been carried out, especially with the engines for driving the pendulum propeller ruder, which engines have given some trouble. A motor with gear coupling did not answer well, and none of the existing valve gears fitted to the ordinary pumping type of engines can be used for higher piston speeds than 4 feet per second, but when driving a pendulum propeller rudder the valve gear should be used for a piston speed of 7 to 10 feet per second; a special valve gear had, therefore, to be constructed, and some years were consumed experimenting with that. A schooner built of oak with nearly 200 tons displacement, seen in the accompanying halftone illustration, 83.3 feet long in the waterline, 19 feet broad, and with 8.3 feet draught of water, was specially built for the purpose of comparing the screw propeller and ordinary rudder with the pendulum propeller rudder.

The funds for these experiments are party derived from private sources, partly from a very rich scientific society (Carlsberg Fondet), and partly from the State, for which reason the work, measurements, etc., during the last four years has been carried out at the Royal Dockyard of Copenhagen. The cause of the support from the last sources was that the pendulum propeller rudder proved superior in efficiency to the revolving propellers and ordinary rudder, both in regard of populsion and maneuvering power. A pendulum propeller rudder d feet long is, however, only able to utilize $\frac{1}{4}$ of the power which a screw propeller of diameter d is able to utilize, as presently to be explained; but in proportion to the power used the pendulum propeller rudder is superior to any other propeller and ordinary rudder.

The Afterend of the Present Pendulum Propeller Schooner.

The above schooner was first equipped with a screw 4.3 feet in diameter and a motor of about 68 indicated horse-power and 41.2 effective horse-power, driving that screw by means of a coupling, when the maximum speed of the schooner was found to be 5.72 knots. In order to use this motor in connection with the pendulum propeller rudder a tooth wheel gear was employed, which fitted splendidly, but as the rigidity of the mounting did not, for different reasons, correspond, the friction became excessive and consumed much power; moreover, the above coupling slipped very much in connection with the oscillating pendulum propeller rudder, where the resistance varied between 0 and maximum. Thirdly, the law of oscillation, being derived from a uniform rotation, thus became almost purely harmonic, and, therefore, too slow at the extremities of the swing. It was not considered worth the trouble to remedy all this, and as a result only about 23 effective horse-power was available for the pendulum propeller rudder and gave a speed of 5.1 knots. In order to obtain satisfactory results with the maneuvering, the sliding parts of the above coupling were secured firmly, so that probably 34 effective horse-power were now available for the pendulum propeller rudder. Under these conditions the schooner turned 360 degrees nearly on the spot in 2 minutes 20 seconds, whereas the screw with ordinary rudder and 41 effective horse-power used 3 minutes 9 seconds in a circle 3.4 times the length of the ship.

Now the schooner has neither screw nor ordinary rudder, but is furnished with a pumping type of engine, driving two pendulum propeller rudders, as seen in the illustration. The present pendulum propeller rudders were designed for an engine of about 80 indicated horse-power, but on account of the cost we only obtained an engine of half that power, which can, however, be forced up to about 45 indicated horse-power; at 43 indicated horse-power (21.5 on each pendulum propeller rudder), corresponding to about 36 effective horse-power, the speed became 6.05 knots at 64 double swings per minute of the pendulum propeller rudder. The time for turning 360 degrees nearly on the spot is as before.

The power required to obtain 5.72 knots is now, as seen on the curves, 36.2 indicated horse-power, corresponding to about 31 effective horse-power, whereas the screw as mentioned used quite 41 effective horse-power for that speed. A larger steam-driven screw would have been more efficient than the one tried, but nevertheless none of the known revolving propellers could have driven the above very full wooden schooner at a speed of 6.05 knots at 43 indicated horse-power, which also was ascertained by actual towing experiments carried out.[2]

The objection raised to side pendulum propeller rudders, as seen on the photo of the schooner, is that they are rather much exposed, and for that reason it was necessary to reduce the swing to 60 degrees, while it ought to have been 80 degrees or 90 degrees, giving greater efficiency. It is, in fact, better to have the pendulum propeller rudders one a little above the other, issuing from the stern, as seen on the attached arrangement, showing the after-part of a ship with pendulum propeller rudders (see the first three drawings on the following page).

In order to understand the action of the pendulum propeller rudder, we refer both to the half-tone and to the sketch of an afterpart of a ship. When the pendulum propeller rudders are not oscillating they are used just as ordinary rudders. R is the rudder, having its rudder stock r inside the hollow arm A, which, by means of horizontal rocking shaft a, to which A is rigidly connected, can be oscillated 30 degrees to each side of the vertical. R's rudder stock r (inside A) is, by means of a universal joint u, connected to the vertical steering shaft s, on the top end of which is a disk d, and helical springs g connect d to a worm wheel w, which is turned by a worm o. When o is turned (more or less directly) by means of an ordinary steering wheel, then w is turned, and w turns, by means of the springs g (connecting d and w), the whole system d, s, u, and r with R. When R is turned 180 degrees from the position shown, it comes into the position for going astern.

When A with R swings, the water presses upon R and turns it in relation to A as much as the springs g (between d and w) permit, so that the springs g determine the pitch of the pendulum propeller rudder. The universal joint u conveys the turning or rocking of the rudder stock r to the steering shaft s. When R is turned, say 30 degrees to starboard and kept there, because the worm gear (o and w) acts like a brake, then in swinging from starboard to port R makes very little resistance (the springs g permitting it to turn an additional angle), but in swinging from port to starboard R acts like a paddle (because the springs g permit R to return to its middle position), thus acting almost perpendicular to the water as paddles and turning the ship forcibly to starboard.

* The article here presented to our readers appeared in part in the *Steamship*. The version here given is specially revised and extended by the author himself for the SCIENTIFIC AMERICAN SUPPLEMENT.

[1] The subsequent fate of the above launch was as follows: It was fitted with a 16 horse-power motor, which by means of a transmission drove the pendulum propeller, but this transmission had to be concealed in the bottom of the launch and therefore became complicated and consumed much power, so that only 12 brake horse-power became useful for the pendulum propeller. The stern of the launch also became very clumsy for that reason. The Russian officers submitted to the vibrations, but after a while they got tired of some particularly bad shocks on starting the motor, and they desired to try a screw propeller instead. As however a screw propeller could not work properly behind the said full stern of that launch, it was cut over at the center, and a new afterpart with finer lines was fitted; the screw was then directly connected to the motor and gave a speed of 8 knots at 16 brake horse-power corresponding to 14 horse-power at 7.7 knots (obtained by pendulum propeller). The trouble with the motor, however, continued, so finally both motor and screw were removed and the launch was fitted with oars and sails.

[2] The reason for the higher efficiency of the oar results from the fact that it—in a higher degree *than possible* with a revolving propeller—accelerates the fluid from zero, and as a thrust $t = ma$ (m = mass, a = acceleration) then the greater the mass and the acceleration (of the fluid operated upon) the greater is the thrust. A screw will, therefore, in the time interval from having no speed and until its full speed is obtained yield quite 33 per cent greater thrust than when revolving with constant speed. If the screw then, as soon as its constant speed is obtained, could be moved aside of the current it had created, and commence anew from 0, then much power would be saved; speed consumes power, the oscillating propeller is therefore stopped as soon as it commences to consume too much power, and must then commence anew. It is therefore impossible for a revolving propeller to rival an oscillating propeller.

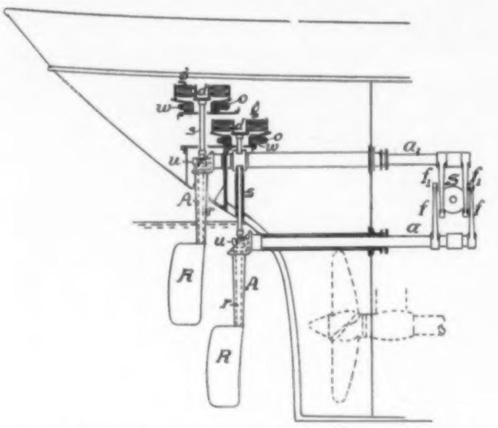


Fig. 1.—Side View of Stern Fitted With Two Pendulum Propellers.

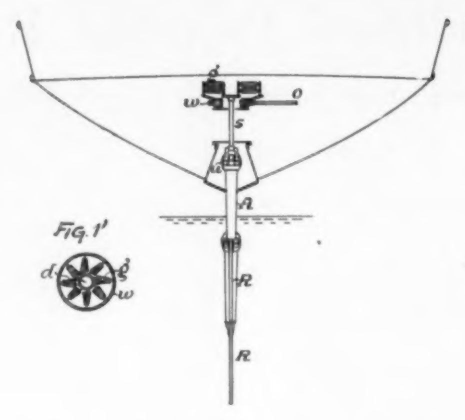


Fig. 2.—Rear View, Showing the Stern and the Pendulum Propellers.

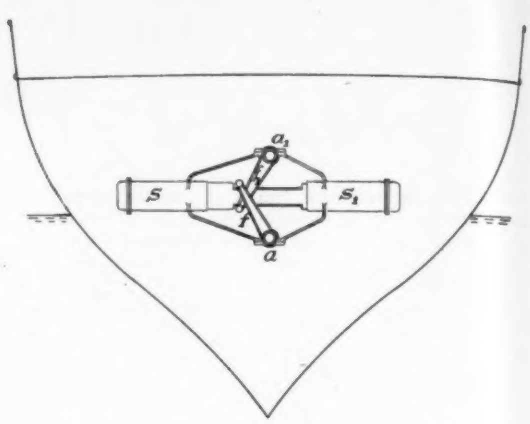
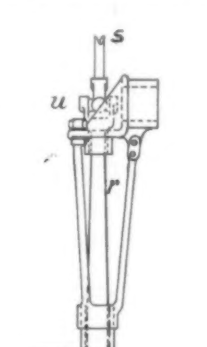


Fig. 3.—View Showing the Arrangement of the Engine on the Ship.

One man can steer a pendulum propeller rudder for the very biggest ship, because in one swing or the other R will always turn itself into the desired position, and be kept there (the worm gear acting like a brake) until again moving the steering wheel. Only when turning R from ahead to astern position against the motion of the ship, then the same power is required as with an ordinary rudder; it is convenient to stop the engine during this maneuver.

The springs g seem big because they are only (as hitherto constructed) strained to about 20,000 pounds to the square inch, or not half as much as customary; they should, therefore, last longer than carriage springs which are of coarser material and much more strained. It is a matter of one minute to remove and replace a spring from its taps; many springs are used filling the annular space between d and w. (See Fig. 1.)



Figs. 4, 5, 6.—Details of 6,500-pound Pendulum Propeller.

Whether pneumatic springs possess greater elasticity than fine steel springs has not yet been ascertained with certainty.

The power which can be put on a pendulum propeller rudder is limited because its speed of oscillation and also its area is limited, and it is useful to know the most dominating extra forces brought into action, which can be found by the well-known formula

$$\tfrac{1}{2} I w^2 = \int_0^{\psi} M \, d\psi,$$

where I is the moment of inertia of the pendulum propeller rudder, w its angular velocity when oscillating, M the corresponding torque, ψ the angle of turning; so that $\frac{1}{2} I w^2$ determines the energy of the turning moment or torque stored in the pendulum propeller rudder. We will first treat the energy represented by $\frac{1}{2} I w^2$, and then the centrifugal force acting on the pendulum propeller rudder when oscillating.

The pendulum propeller rudders seen in the half-tone illustration weigh about 380 pounds each and are 6 feet long; their moment of inertia I is about 140; their angular velocity w when making 64 double swings per minute (corresponding to 6.06 knots at 43 indicated horse-power) is 2.2, a swing being about 60 degrees; their kinetic energy $\frac{1}{2} I w^2 - \frac{1}{2} \times 140 \times 4.8 = 336$ feet pounds in the middle of the swing, but only about 180 foot-pounds four inches from the end of the stroke on each side, where the compression in the present pumping-type engine commences; the lead begins 1.25 inch from the end of the stroke, which is 37 inches long; the piston area is 80 square inches and the steam pressure varies from 60 to 100 pounds. The compression together with the water resistance, when the springs G return the driving surface R to its central position, are quite sufficient to take up the energy $\frac{1}{2} I w^2$, amounting to $2 \times 180 = 360$ foot-pounds on both. The centrifugal force $\frac{m v^2}{r}$ is unbalanced, but of no consequence in this case, only amounting to 350 pounds on both pendulum propeller rudders together. The force of gravity is of course a benefit, accelerating the motion at the commencement and retarding at the end of the swing.

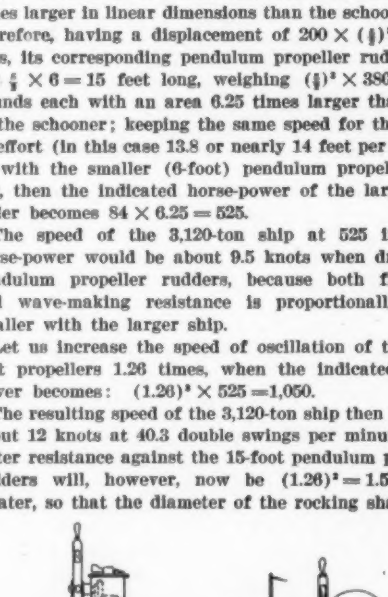
We shall now carry out an estimate by analogy from the present schooner to larger ships and powers. As basis we use the power corresponding to 80 double swings, which is: $(\frac{80}{64})^3 \times 43 = 84$ indicated horse-power, the propeller being designed for about that power. The corresponding speed is: $6.05 \times \sqrt[3]{\frac{84}{43}} =$ 7.56 knots. The energy $\frac{1}{2} I w^2$ now becomes 1,078 foot-pounds on both pendulum propeller rudders together, but only a little over half that when the compression commences, and that energy is easily taken up in the manner described. The maximum centrifugal force now amounts to 500 pounds on both propellers together or less than $\frac{1}{708}$ of the weight of the ship. There is, therefore, no trouble about that.

Let us consider the conditions with a similar ship $\frac{5}{2}$ times larger in linear dimensions than the schooner and, therefore, having a displacement of $200 \times (\frac{5}{2})^3 = 3{,}120$ tons, its corresponding pendulum propeller rudders being $\frac{5}{2} \times 6 = 15$ feet long, weighing $(\frac{5}{2})^3 \times 380 = 5{,}930$ pounds each with an area 6.25 times larger than those of the schooner; keeping the same speed for the center of effort (in this case 13.8 or nearly 14 feet per second) as with the smaller (6-foot) pendulum propeller rudder, then the indicated horse-power of the larger propeller becomes $84 \times 6.25 = 525$.

The speed of the 3,120-ton ship at 525 indicated horse-power would be about 9.5 knots when driven by pendulum propeller rudders, because both frictional and wave-making resistance is proportionally much smaller with the larger ship.

Let us increase the speed of oscillation of these 15-foot propellers 1.26 times, when the indicated horse-power becomes: $(1.26)^3 \times 525 = 1{,}050$.

The resulting speed of the 3,120-ton ship then becomes about 12 knots at 40.3 double swings per minute. The water resistance against the 15-foot pendulum propeller rudders will, however, now be $(1.26)^2 = 1.59$ times greater, so that the diameter of the rocking shafts and



Figs. 8, 9.—Details of Steering Wheel.

of the arms A increases $\sqrt[3]{1.59} = 1.17$ times, making the resisting area of the arm A $(1.17)^2 = 1.37$ times greater, so that the weight of the 15-foot pendulum propeller rudders becomes $1.37 \times 5{,}930 = 8{,}124$ pounds, but when constructed as shown on Figs. 4, 5, and 6 its weight is reduced to 6,500 pounds, and the weight of both to about 13,000 pounds. The energy $\frac{1}{2} I w^2$ of both pendulum propeller rudders together (in the middle of the swing) is now nearly 30.000 foot-pounds and about 16,000 foot-pounds when the compression in the engine commences. This energy is easily taken up by the water resistance. It is therefore not the energy represented by $\frac{1}{2} I w^2$, which limits the speed of oscillation, but it is the centrifugal force, which, however, in this case amounts to only 2,970 pounds on each propeller and to 5,940 pounds on both together, say 2.9 tons or to about $\frac{1}{1108}$ part of the weight of vessel, so there is absolutely nothing to prevent 1,000 to 1,200

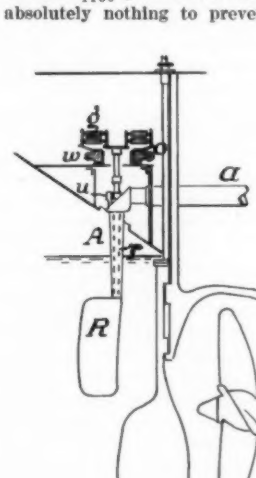


Fig. 7.—Stern of Ship Fitted With a Single Pendulum Propeller.

indicated horse-power being applied on a pair of 15-foot pendulum propeller rudders.

Let us view the problem from another standpoint: When comparing rectilinear and rotational motion of matter we must consider the energy represented respectively by $\frac{1}{2} M v^2$ and $\frac{1}{2} I w^2 = \frac{1}{2} M r^2 w^2$, where M represents mass, v rectilinear speed, I moment of inertia, r radius of gyration, and w angular velocity, so that v corresponds to $r w$. The moment of inertia of a pendulum propeller rudder of length L is found to be nearly equal to that of a homogeneous rod of length l, swinging about one end, the I of the rod being $\frac{1}{3} m l^2$. The radius of gyration r of our 15-foot pendulum propeller rudders is then approximately

$$r = \sqrt{\frac{\frac{1}{3} m l^2}{m}} = \sqrt{\tfrac{1}{3} . 15^2} = 8.66$$

so that the speed $r w$, at 40.3 double swings per per minute (where $w = 1.4$) becomes: $8.66 \times 1.4 =$ 12.12 feet per second (the speed of the center of effort becomes 17.5 feet per second). The value $r w =$ 12.12 feet per second is very small as compared with the speed v of the oscillating masses of a large engine, where $v = 20$ feet per second is considered a limit, though a rather vague limit, for the larger the engine and the larger the pendulum, the greater may be their speed. If the length of a pendulum is increased N times, the velocity of its center of oscillation will be multiplied by $\sqrt{N}$. Our 15-foot pendulum propeller rudder would by gravity alone make about 17 double swings per minute, and if gravity became 5.2 times

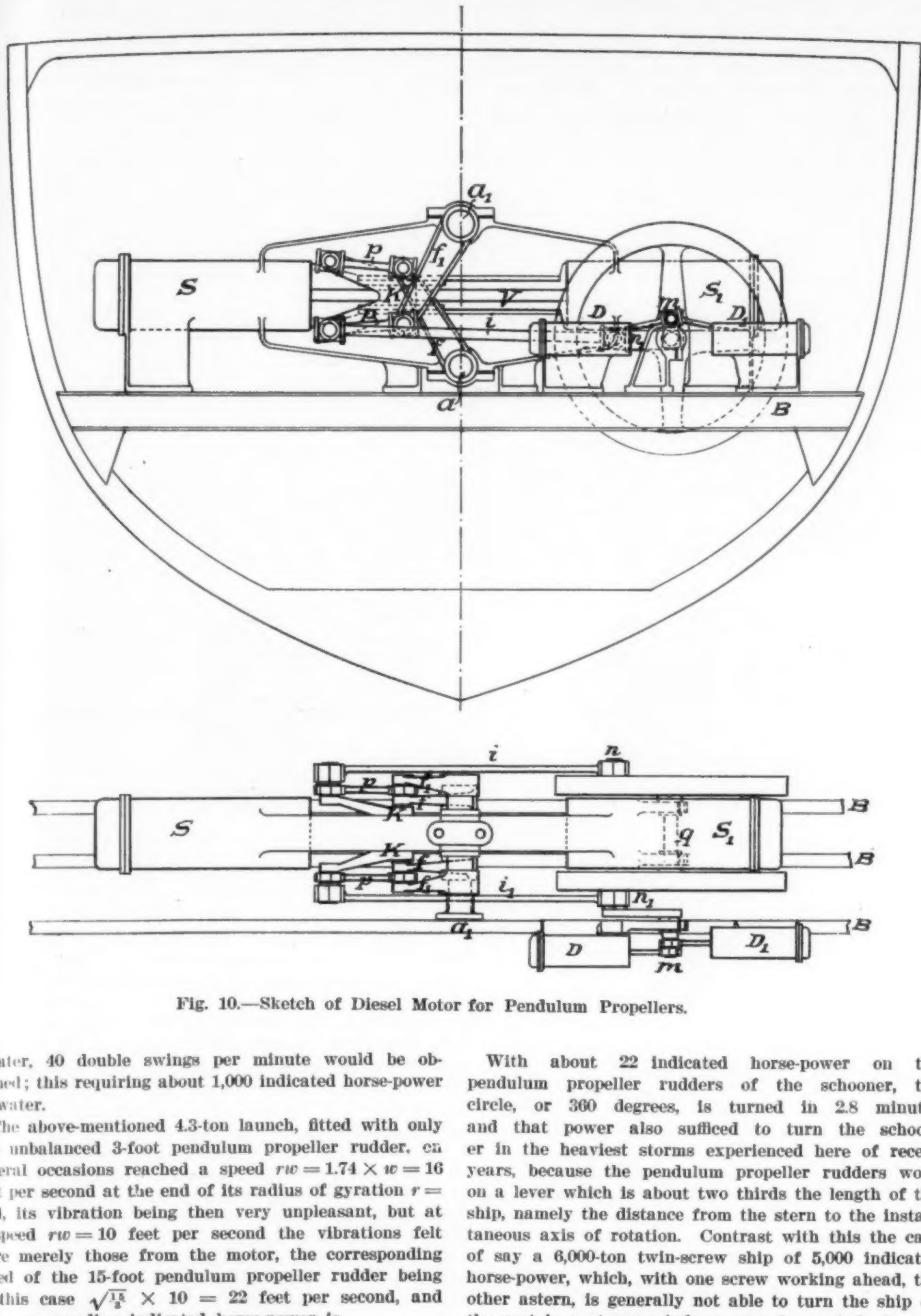


Fig. 10.—Sketch of Diesel Motor for Pendulum Propellers.

greater, 40 double swings per minute would be obtained; this requiring about 1,000 indicated horse-power in water.

The above-mentioned 4.3-ton launch, fitted with only one unbalanced 3-foot pendulum propeller rudder, on several occasions reached a speed $rw = 1.74 \times w = 16$ feet per second at the end of its radius of gyration $r = 1.74$, its vibration being then very unpleasant, but at a speed $rw = 10$ feet per second the vibrations felt were merely those from the motor, the corresponding speed of the 15-foot pendulum propeller rudder being in this case $\sqrt{\frac{15}{3}} \times 10 = 22$ feet per second, and the corresponding indicated horse-power is

$$\left(\frac{22}{12.24}\right)^3 \times 1,050 = 6,090,$$

which causes a highly augmented pressure on the water and a corresponding increase in the strength required, as the weight and centrifugal force are increased to respectively 14 tons and 20 tons on both propellers together, so that the entire centrifugal force here amounts to $\frac{1}{150}$ of the weight of the ship. Now with similar ships the capacity for resisting such forces varies as the fourth power of the linear dimensions of the ship, but the resisting areas only vary as the second power, so that very considerable extra strengthening would be required. This would make it impracticable to use so much power on the above two 15-foot pendulum propeller rudders; but 1,200 indicated horse-power will answer very well. Four pendulum propeller rudders can easily be worked by one engine or motor, but the side pendulum power rudders ought then to be made removable for harbor service.

The pendulum rudders are limited as regards speed of oscillation, and the only compensation for this is sufficient area (as used in nature) for which there is also a practical limit. When therefore a high horse-power is required, the pendulum propeller rudders will have to work in conjunction with screw propellers. If for instance it is required to drive a 6,000-ton ship with 3 screws worked by 3 Diesel motors, each of 1,100 horse-power, then instead of the stern screw consuming 1,100 horse-power, a pair of pendulum propeller rudders, consuming 1,000 horse-power, should be used, for 1,000 horse-power applied to a pair of pendulum propeller rudders yield the same effect as about 1,130 horse-power applied to a screw propeller; and by a turn on the steering wheel, these 1,000 horse-power will be rendered effective in turning the stern about, just as if a tugboat of that power were pulling sideways on the sternpost.

With about 22 indicated horse-power on the pendulum propeller rudders of the schooner, the circle, or 360 degrees, is turned in 2.8 minutes and that power also sufficed to turn the schooner in the heaviest storms experienced here of recent years, because the pendulum propeller rudders work on a lever which is about two thirds the length of the ship, namely the distance from the stern to the instantaneous axis of rotation. Contrast with this the case of say a 6,000-ton twin-screw ship of 5,000 indicated horse-power, which, with one screw working ahead, the other astern, is generally not able to turn the ship on the spot in a strong wind, or even in a wind of average strength, because the leverage of the twin screws is only about 1/3 of the breadth of the ship, and as the thrust of the screw working astern is only about 2/3 of the other's thrust, thus the turning couple of the screws is reduced by 1/3; there is also a slight translational velocity preduced by the ahead screw. The water and wind resistance of such a ship, concentrated at a center of effort located 3/4 of the way along the ship from the screws, works against the moment of the turning couple.

Judging by analogy from our 200-ton schooner, a pair of pendulum propeller rudders would turn a similar 6,000-ton ship on the spot (360 degrees) in 8.4 minutes and require 204 indicated horse-power for this. Turning the 6,000-ton ship in 5 minutes would require $(\frac{8.4}{5})^3 \times 204 = \frac{593}{125} \times 204 = 959$ indicated horse-power. But 959 indicated horse-power on a pair of pendulum propeller rudders yield the same driving effect as 1,080 indicated horse-power on a screw propeller.

We shall now consider a very important matter, namely, the engine or motor for the pendulum propeller rudders: In Diesel motors as well as in ordinary steam engines, the motion produced is primarily an oscillating motion of the piston, piston rod, etc., and as the pendulum propeller rudder only requires oscillating motion, it must be clear that a simpler engine can be made for the oscillating pendulum propeller rudders than for the revolving propellers—because there is necessarily a loss in transforming oscillating motion into revolving motion.

Fig. 10 shows a sketch of a Diesel motor destined for pendulum propeller rudders; 2 cylinders S and S_1 are seen opposite each other and the pistons in these cylinders are connected by a common piston rod V. The rocking shafts a and a_1, together with their rocking arms f and f_1, are seen the one above the other, and small connecting rods p issuing from the crosshead k drive the arms f and f_1. Conecting rods i and i_1 are also seen proceeding from the crosshead k to the crank pins n and n_1 of two symmetrical flywheels. The main motor is shown in its dead center position, but a small motor with cylinders D and D_1 works on a crank which is in its middle position when the main engine motor is at its dead center and *vice versa*, so that dead centers are avoided. In order to avoid harmonic motion the flywheels must not be too large, because they should be accelerated at the extremities of the swing, so as to permit a law of oscillation similar to that resulting from a pumping type of engine. B are beams on which the motor rests.

It will be seen that the stroke in the described type of motor is long without unduly lengthening the motor, and a long stroke permits of a good expansion. At 1,050 indicated horse-power our pair of 15-foot pendulum propeller rudders make 40.3 double swings per minute, which seems a rather small number, but the stroke being 7 feet, the piston speed becomes 9.34 feet per second, which is very considerable. It is furthermore a considerable gain that the motor occupies very little space in the longitudinal direction of the ship as compared with the motor for a screw propeller (space occupied along the beam of the ship is not so important). Another important advantage is that this motor requires no reversal, and that the pistons and piston rods form one hollow body in which a cooling fluid can be circulated (the awkward bearing in the piston is avoided).

The same type of engine can be used for steam, the intermediate and low-pressure cylinders lying opposite each other with one common piston rod for their pistons, just like the cylinders S and S_1, and the high pressure cylinder from which the regulating rotary motion is derived is placed alongside one of the larger cylinders.

The improved pumping-type engine now used in the schooner is, of course, the simplest of all engines, but in a seaway it happens that the piston strikes the covers, and when the pendulum propeller rudders are put over to an angle of more than 30 degrees, the same exceptionally happens (critics have found fault with this point); but with introduction of proper elasticity to the system, we might say, what does it matter if the piston exceptionally strikes the covers, it is never a hard blow, because the piston has first to pass the compression and the lead before striking. Moreover, when suddenly stopping the piston, then the rudder R turns farther round A, giving of its residue energy $\frac{1}{2} I w^2$ to the water. There is something nice and efficient in having this direct balance between the steam pressure on the piston and the water pressure on the rudder R. However, we have been obliged to yield upon this point.

In ships with one screw we have the choice between two pendulum propeller rudders, one on each quarter of the ship, where their superior propulsive qualities partly come to their right, but where they are rather exposed, or of one pendulum propeller rudder behind an ordinary short-balanced rudder—as shown on Fig. 7—and where the pendulum propeller rudder should only be oscillated under specially difficult circumstances, but under general circumstances used as ordinary rudder. Steering two pendulum propeller rudders with two steering wheels (close to each other) works excellently. Generally only one of the pendulum propeller rudders is used for steering while the other is left only to yield propulsion, but when sharp turnings are required both steering wheels are worked. Exactly the same might be done with one ordinary short-balanced rudder and one pendulum propeller rudder.

As auxiliary propellers for sailing ships the pendulum propeller rudder is, of course, superior to all others; the ordinary screw does not only damage the shape of the ship's stern, but also its progress under sail. The appliance of the pendulum propeller rudder does, of course, neither hurt the ship's shape nor its progress under sail, and no other rudder is required unless the power at disposal is small, so that only one pendulum propeller rudder is desired, as on Fig. 7 (without screw). The experiments with the Danish frigate "Fyen" and with the gun-boat "Hauch" in order to find the horse-power developed by sails have been published in *The Steamship*. It was thus shown that an extra push from a propeller might increase the horse-power developed by the sails 3 times, when having side wind or sailing close hauled; the main reason for this being that a ship's resistance against leeway almost varies with the square of its speed, thus being almost 4 times greater at 6 knots than at 3 knots, but the principal condition for carrying sails is proper side resistance against leeway. A correctly-rigged sailing ship, with such auxiliary power that its speed never sinks below 6 to 7 knots, must be an economic cargo carrier.

Summarizing the most important facts, let it not be forgotten that most calamities at sea happen at low

speeds, where the ordinary rudder often becomes a dead and useless thing, being totally dependent on the speed of the ship. Thus in foggy weather, where a high maneuvering power is of importance in order to avoid collisions, etc.; also in much-frequented fairways, shoaly waters, etc., and on entering harbors with wind and wave astern; also in stormy weather with heavy seas, when only little speed can be maintained, a high maneuvering power in order to avoid falling into the trough of the waves is desirable, etc. Moreover, the pendulum propeller rudder in itself is as efficient when going astern as when going ahead, so that full maneuvering power is obtained also when moving astern.

It can be shown by calculation that the theoretical efficiency of an ideal oscillating propeller is 25 per cent higher than that of an ideal revolving propeller, but probably only about 14 per cent will (for different reasons given) be obtained. Notwithstanding the 70 years' experience with the screw propeller, the present pendulum propeller rudder is considerably superior to it in efficiency.[2]

It is intended to send out the schooner on a cruise, because a perfectly new matter like this is seldom understood nor believed in unless persons interested in it may try it themselves by means of direct measurements.

Thus the turning of the schooner is so smooth that the finest aim can be taken with it, a matter which might come to use in floating gun carriages for coast defense.

[2] The latest investigations have proved that two pendulum propellers 12 feet long and in the position shown on Figs. 1, 2, 3, where they are able to swing 90 degrees (instead of now scarcely 60 degrees) can without any trouble transmit 1,200 horse-power at 40 double swings per minute, i. e., sufficient for a ship of 8,000 tons displacement at 10 knots.

High-Frequency Generator

For Wireless Telegraphy and Telephony

By E. F. W. Alexanderson

The object of this paper is to indicate the probable course of development in the wireless art rather than to give detailed descriptions of apparatus which is in use at the present time, information upon which can always be obtained from modern text books and current literature.

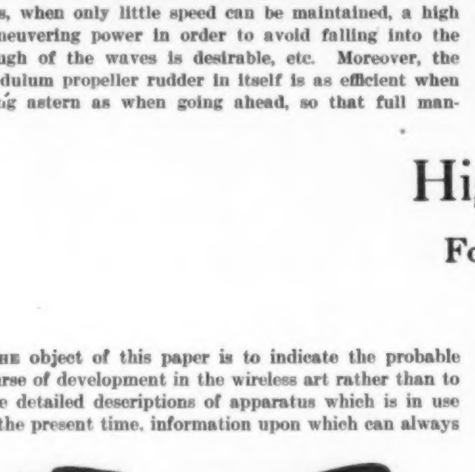


Fig. 1.—D-C Armature, A-C Pole Face Winding and D-C. Field Coil of a 2,000-Cycle Converter.

Of recent years the station equipment for transmitting messages without wires has become more or less standardized, the generating apparatus usually being designed to furnish a current having a frequency of approximately 500 cycles. A high-voltage transformer is introduced into the 500-cycle circuit and is arranged to create a spark impulse during every half-cycle. The details of the various equipments differ in the arrangement of the spark circuit, but the general tendency is the same, viz., to suppress the arc in the spark circuit immediately after the first energy impulse has been given, so as to leave the high-frequency circuit free to swing, with its natural period of oscillation, without any tendency to pump back into the generating apparatus.

The introduction of the 500-cycle generator marked a great improvement upon earlier methods, because of the increased efficiency which was obtained in both the sending and the receiving circuits. Upon observation it became clear that the human ear is most sensitive to energy impulses at a rate of 1,000 per second, which corresponds to an alternating current of 500 cycles. Furthermore, comparing a 500-cycle system with those in which a lower frequency is employed, an additional advantage lies in the fact that it is possible to transmit a greater amount of energy with the same size of antenna, since the energy which can be transmitted at any one impulse is limited, and the average energy is proportional to the number of impulses per second. The currents transmitted by this system partake of the nature of an impulse at every one thousandth of a second, a train of waves following the impulse with a decreasing amplitude, and with a frequency depending upon the natural frequency of the antenna and the tuning arrangement used in combination therewith. The receiving apparatus for handling the messages consists of a telephone. Inasmuch as the telephone cannot respond to the high frequency of the electric waves, a form of rectifier must be interposed so as to change the vibrations into a unidirectional flow of current. With such an arrangement, the telephone receives 1,000 current impulses per second all in the same direction, and the membrane of the telephone gives a note which is perceived by the operator.

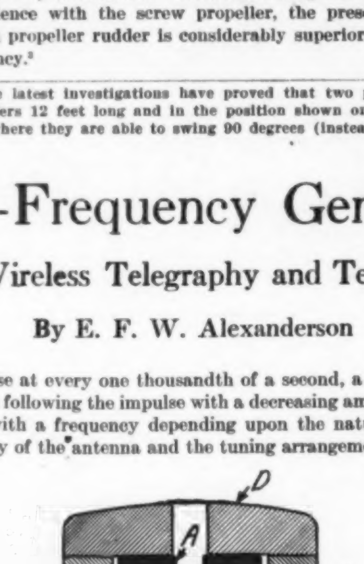


Fig. 2.—Partial Section Through High-frequency Alternator.

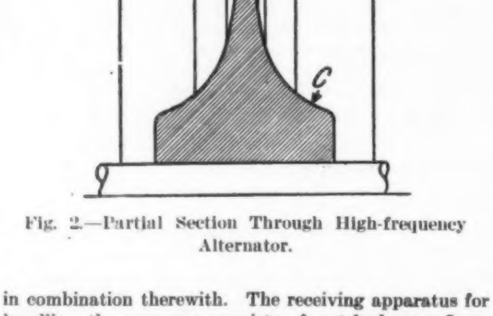


Fig. 4.—Rotor of Standard 100,000 Cycle Alternator.

There is no doubt that the apparatus in use at the present day will be considerably simplified and improved; and it may be of interest here to give a brief description of a type of 500-cycle alternator which has been developed by the author in order to simplify the generating equipment used with the spark method of transmission. The object in mind here has been to provide a machine that will occupy less space than the former equipment, while at the same time reducing the cost. Briefly, the apparatus simplifies the generating unit mentioned above by combining in a common frame both the direct current and alternating current windings. The economies which have thereby been effected are of the same nature as those which are inherent in the ordinary synchronous converter as compared with the motor-generator set, although the principle which has been adopted is somewhat different. In the ordinary converter, the alternating current and direct current circuits make use of the same field and also the same armature winding, in which case the frequency of the alternating current must bear a definite ratio to the number of poles and the speed of the direct-current motor. In the 500-cycle converter there is no relation between the alternating frequency and the frequency in the direct current armature, but nevertheless the same magnetic field and the same winding for field excitation are employed. The principle of the machine is as follows: In any direct-current motor or generator, eddy currents are generated in the pole faces. The energy produced by these eddy currents is suppressed as far as possible by the use of laminated poles designed to break up the eddy current circuit. In the 500-cycle converter, eddy currents are emphasized and represent the output of the machine. These currents are generated on a winding suitably placed in the face of the stationary pole. The magnetic structure of the alternating current winding is shown in Fig. 1, which represents a 2,000-cycle converter built on the same principle as the 500-cycle converter. The machine is made from a standard direct-current motor, and the alternating cur-

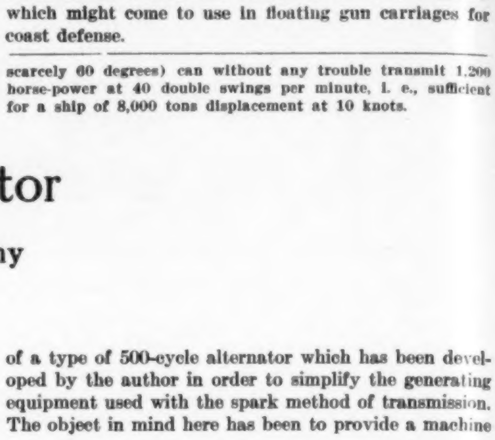


Fig. 3.—Rotor and Shaft of Standard 100,000 Cycle Alternator.

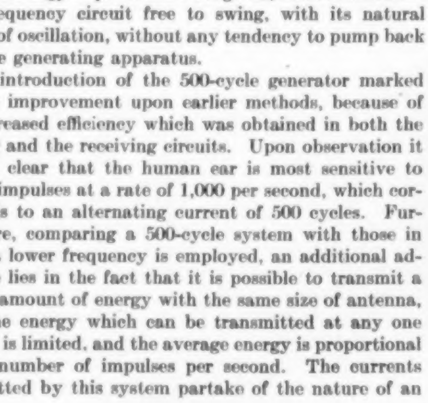


Fig. 5.—Stationary Field and Armature of Single-phase Telephone Relay.

Fig. 6.—2 Kv.-a. 100,000 Cycle Alternator Driven Through Single-reduction Gearing by Direct Current Motor.

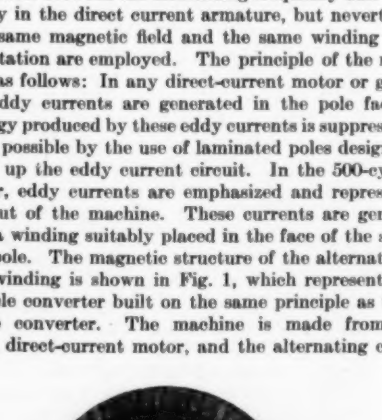


Fig. 7.—Revolving Disk of Single-phase Telephone Relay.

rent winding does not occupy any space that would be used for any other purpose.

THE ADVANTAGES OF THE HIGH-FREQUENCY SYSTEM.

Although considerable economies are effected by the substitution of a single-unit converter for the two-unit motor-generator set, and although, as has been pointed out, the present phase of the wireless art refers almost exclusively to telegraphy conducted by the spark method using 500-cycle generators, there are a number of reasons which lead one to the belief that this type of wireless outfit will, in the near future, be superseded by the system in which a continuous train of waves is used, generated by high frequency alternators. These reasons briefly are as follows:

(1) The antenna is the most expensive part of a sending station, and the radiating power of any certain antenna is much greater with continuous train of waves than it is with the spark method. With the spark system the antenna receives 1,000 energy impulses in a second, each of which is followed by a train of waves as far as it is possible. With the high-frequency alternator, however, the same antenna will receive 200,000 or 400,000 energy impulses per second if the 100,000 and 200,000 cycle alternators are used. The radiating power of the antenna is limited by the break-down voltage of the air during any one impulse, and therefore it is obvious how it can be used to greater advantage with the increased number of impulses.

(2) The voltages induced in electric circuits in the proximity of the sending stations are apt to be very high, and it is possible that rules of legislation may be introduced in order to protect property from destruction. The advantages of the high-frequency alternator apply for the same reasons as above. Inasmuch as the number of energy impulses per second is so much greater, the voltage involved in each impulse may be correspondingly lower to radiate the same energy; and the consequent induction and destructive effect on other electric circuits will be correspondingly lower.

(3) The possibilities for tuning, or elimination of interferences, are much greater with the high-frequency alternator system. With the spark system each impulse is followed by a short train of rapidly dying waves, and the number and power of the successive waves give the possibility for tuning. If only the initial wave were radiated, no tuning would be possible. With the high-frequency alternator the wave train is continuous, and the possibility for selective tuning is limited by practically nothing else than the possibilities for maintaining a constant speed of the generating apparatus.

(4) The spark system is used for telegraphy only, and cannot be used for the telephone; whereas a high-frequency alternator system can be used equally well for both telegraph and telephone. In the former method, the only note that can be transmitted and received by the telephone is one which has a frequency corresponding to the 500-cycle generating apparatus, and a signal can be given only by interrupting the sound in accordance with the Morse telegraph system. In order to transmit articulate speech, it is necessary that a continuous flow of energy be used, which can be modulated in accordance with the vibrations of the human voice in articulate speech. In the 500-cycle commercial equipments all the requisite apparatus is present for the transmission of telephonic speech with the exception of the generating apparatus and the transmitter. The sending antenna with its tuning apparatus, the receiving antenna with its detector apparatus, and the telephone receiver are built on the same principle, whether they be used for telegraph or telephone. Inasmuch as a trans-atlantic communication by wireless telegraphy has been established for some years on a commercial basis, it is probable that it will soon be followed by a corresponding telephonic communication, and that the wireless telephone will be as much more important for business purposes as the wire telephone is more important than telegraphy. With regard to the design of a telephone transmitter capable of handling sufficient power, various schemes for overcoming the difficulties have been proposed; and it is probable that the next few years will see the apparatus available in commercial form.

HIGH-FREQUENCY GENERATING APPARATUS.

The high-frequency alternator designed by the author is the result of several years of experimental work undertaken at the request of Prof. Fessenden. When this work was begun, although the use of continuous trains of waves for wireless transmission had been contemplated, no means had been provided, or were even believed possible, for generating such frequencies as were required for this method of transmission. In 1908 the author, in a paper before the American Institute of Electrical Engineers, described an alternator built for 100,000 cycles, previous to which the highest frequency which had been produced was 10,000 cycles—entirely inadequate for the purpose in hand. It was thought at the time that the 100,000-cycle alternator represented nearly the limit of what could be achieved. Since that time, however, a machine has been built for directly generating frequencies of over 200,000 cycles; while a frequency of 400,000 cycles has been produced by the use of this same machine in combination with a mercury arc rectifier.

The alternator is of the inductor type, and is provided with a novel arrangement of the magnetic circuit, allowing the construction of a rotor which can be operated at exceedingly high speeds. In the final form of the alternator (shown in section in Fig. 2), the rotor, *C*, consists of a steel disk with a thin rim and hub shaped for maximum strength. The field excitation is provided by two coils, *A*, located concentric with the disk and creating a flux that passes through the cast-iron frame *D*, the laminated armature with its teeth, and the disk. *B* represents the two armatures which are secured in the frame by means of a thread, in order to allow an adjustment of the air-gap, the laminations carrying the conductors being located at *E*. Instead of poles or teeth, the disk *C* is provided with slots which are milled through the thin rim so as to leave spokes of steel between the slots. The slots are filled with a non-magnetic material which is riveted in place solidly, in order to stand the centrifugal force and to provide a smooth surface on the disk so as to reduce air friction.

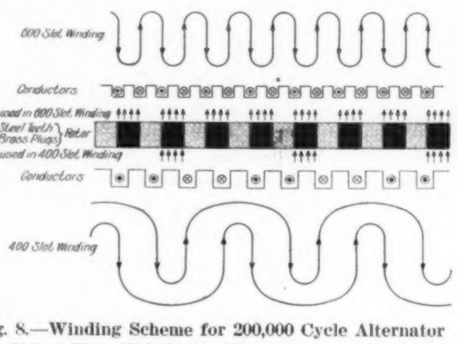


Fig. 8.—Winding Scheme for 200,000 Cycle Alternator Using Two Thirds as Many Slots as Effective Number of Poles.

The standard 100,000-cycle rotor with 300 slots is shown in Figs. 3 and 4. A complete view of a commercial high-frequency alternator is shown in Fig. 6. The set is driven by a direct-current shunt motor fitted with commutating poles running at 2,000 revolutions per minute which drives the alternator through a single-reduction, 10 to 1, helical-cut gearing at a speed of 20,000 revolutions per minute. Forced lubrication is provided for all the high-speed bearings, the pressure being derived from a small oil-pump located at the motor end, shown in Fig. 6, and chain-driven from the motor shaft. Reference to Fig. 3 will show that both of the alternator bearings are thrust bearings; and in order to prevent any possibility of binding between these thrust bearings, due to expansion of the shaft from heating, the machine is provided with a system of equalizing levers to compensate for such shaft heating. Any tendency which would cause a change in air-gap is counteracted by the automatic action of the levers. If the air-gap should tend to change at either side, the magnetic attraction at that side would cause an additional pressure and consequent heating on the thrust bearings at that end; and a consequent expansion of the shaft there would bring the rotating disk back to a central position. Without some such arrangement any inaccuracy in lining up the machine, etc., would be cumulative in its action; and the increase of pressure would lead to further wear of the bearings, and further increase of the fault, with the final result that binding would ensue.

A need has arisen for machines of even higher frequencies than 100,000 cycles, but the design of an alternator of this pattern for 200,000 cycles presents considerable difficulties. The standard 100,000-cycle alternator has 600 slots; and consequently the same type of winding for 200,000 cycles would require 1,200 slots. A new type of winding was therefore devised which allows the use of two thirds as many slots as the effective number of poles. Figs. 8, 9 and 10 show the difference between the standard winding and the special winding. Where this special winding is used for the 100,000-cycle alternator, 400 slots are used instead of 600, while in the 200,000-cycle machine, 800 slots are employed instead of 1,200. This form of winding may be applied to the design of machines of even lower frequency than those mentioned, if it is particularly desired to use wider slots and a greater amount of insulation. Both of the foregoing designs embody great simplicity in the construction of the rotor, which allows the use of very high speeds; and a much higher frequency may safely be obtained in this manner by direct generation than can be produced by those designs in which a laminated rotor with windings and collector rings is employed, since the latter construction necessarily involves a lower operating speed.

The transmission of messages by wireless telephone has been carried out successfully over distances as great as 200 miles by the use of the 100,000-cycle alternator. With this machine, the sending circuit becomes extremely simple. The alternator being connected directly between the antenna and ground, generates a potential of 100 to 200 volts, which in itself is rather low for wireless transmission. It is found, however, that by the use of suitable tuning apparatus the potential of the antenna can be raised to the break-down point of the air; so that the sending capacity is not limited by the potential of the alternator, but only by the radiating capacity of the antenna.

From the foregoing description of this alternator, it is evident that the amount of power which can be generated by a machine of any given size decreases with increasing frequency. At moderate frequencies like 50,000 cycles, power can be generated in greater quantities than at such frequencies as 200,000 and 400,000 cycles. This, however, is rather a fortunate circumstance; because a frequency of 50,000 cycles can be used to advantage for transmission over great distances where the antenna is comparatively high and its natural frequency is correspondingly low; whereas small antennæ for short distance transmission require a higher frequency, the required amount of power, on the other hand, being less. The sending apparatus which has been employed up to the present in communication by wireless telephony has been a high-power water-cooled carbon transmitter, designed to handle currents corresponding to the output of the alternator.

In connection with long-distance telephone transmission, it was foreseen some time ago that ultimately a limit would be reached where a sufficiently large power microphone could not be built. The author therefore made some experiments, and several years ago made a successful demonstration with a type of alternator in which a telephone current was used for field excitation, and in which the amount of current generated by the armature had a volume considerably larger than the energy used in the telephone for the purpose of excitation. The principle of this machine was somewhat different from that of the ordinary alternator, inasmuch as one winding was used for excitation and for generating the alternating current simultaneously. This arrangement was adopted because it seemed important that a winding design be employed which would involve the least amount of voltage loss through self-induction in the field winding. The self-induction between field and armature is obviously

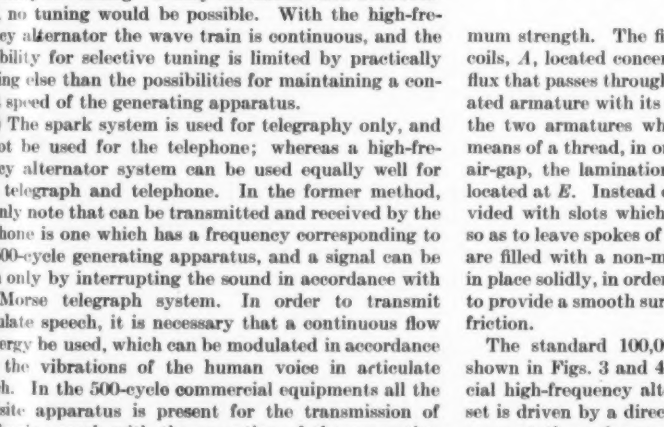


Fig. 9.—Standard Winding for 100,000 Cycle Alternator, With 600 Slots.

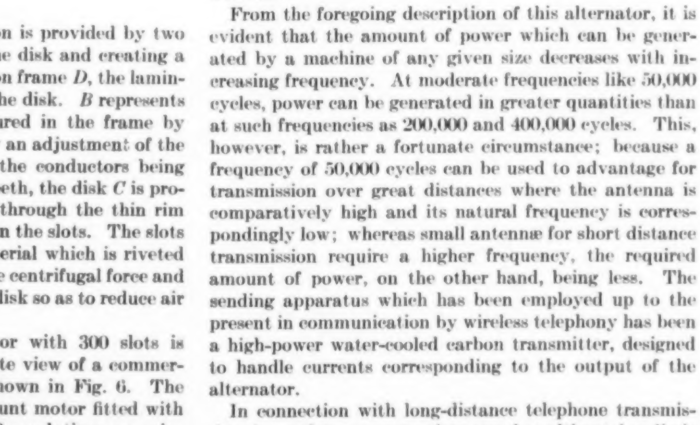


Fig. 10.—Special Winding for 100,000 Cycle Alternator, With 400 Slots.

entirely eliminated where the current flows in the same manner.

Briefly, the principle of this alternator is as follows: If a coil is magnetized by direct current and the magnetic circuit of the same is closed through a moving part which continually varies the air gap, the flux will vary correspondingly, and an alternating electric motor force will be introduced in the magnetizing coil. In its simplest form the device is inoperative because the alternating voltage is short-circuited upon the direct-current exciter. It is, therefore, necessary to use at least two coils connected in such a way that the alternating voltages are induced in opposition in reference to the direct current. This leads to two types of connections. In one the same wire is used for the flow of excitation and the alternating current, the exciting circuit flowing through the two coils in series and the alternating circuit through the same coils in multiple. In the other type of connection different wires are used, the exciting circuit always employing two exciting coils in series so as to eliminate the resulting induced voltage, whereas the alternating-current winding can be connected either in series or in multiple. This type of machine has the characteristics that the coil pitch of the winding has no definite relation to the frequency. The winding may cover either one or as many poles as is desired. The frequency is produced simply by the relation of the teeth of the stationary and rotating members.

The first model of this type that was tried was the telephone relay, which was demonstrated experimentally. It had a winding where each coil comprised one tooth. Subsequently the same machine was rewound so as to employ coils comprising several teeth, the magnetic structure being otherwise the same (see Figs. 5 and 7). The voltage in this type of generator being produced by fluctuations in the strength of the magnetic flux, it is essential that the carrier of the flux on the moving member should also be laminated; and this fact constitutes the limitation of the usefulness of this type of machine.

So far it has not been possible to employ speeds greater than two thirds of the speeds used by a type of alternator with solid steel rotor, and even then with a lower factor of safety. The advantage that might be claimed for the same is the indefinite ratio between the winding pitch and the frequency, which makes it possible to use larger slots than may be used in the purely inductor type of alternator. However, with the improved winding of the inductor alternator described above, using two thirds as many slots as the number of poles, the advantage is minimized. Whatever may be the usefulness of the high-frequency alternator with laminated rotor for special purposes, there is no doubt that the solid steel rotor is better adapted for producing extremely high frequencies; and efforts are being made to find a method to control high-frequency currents of greater intensity than those which can be handled by a carbon transmitter, even if water-cooling is resorted to for increasing its capacity to a maximum. Some experiments in fact have been made with a high-frequency amplifier, which give promise of the same advantages as the use of the microphone in the exciting circuit, as described above; but yet make it possible to use an alternator with solid steel rotor.

Classification of Igneous Rocks*

By H. Warth, D.Sc.

In the method described below I have based the partition of rocks into classes not upon individual bases, but upon the respective sums of bases of equal valency, as determined from molecular percentages. We call these sums respectively T, D and M (tri-, di- and monovalent). One thousand rocks were selected from the current literature and their molecular percentages calculated in the usual manner. A dichotomous division was then carried out. We first calculate the mean value or constant of D for the whole of the rocks. We then separate all the rocks into a set "a" which have a value of D smaller than the mean 17.83, and a set "b" which have a value of D larger than 17.83. Each of these sets we then divided once more according to the respective averages of another constant, obtaining "a a," "a b," "b a," "b b," as shown graphically by blank and shaded rectangles (pigeon holes) in diagram No. 1. The following are six constants which were used in succession:

$$D, T + D, T + D + M, D + M, T + M, M.$$

They yield us 2^6, equal to 64 sets or groups of rocks, and the rocks of each group are of closely similar molecular composition. Herewith will be found a table showing the mean values of T, D and M of each group, also the respective mean totals of acid constituents A, which sum up to 100.0 with the other three values.

Diagram No. 2 represents these results graphically. We have abscissæ equal to the numbers of rocks, and ordinates equal to T, D and M, while A follows above the latter and extends up to a horizontal line which falls beyond the paper. A striking feature of diagram No. 2 is the gradual and finally very considerable increase of divalent bases in the order of decreasing acid constituents. (Compare with another diagram *Geol. Magazine*, p. 273, June, 1900.)

*Slightly abridged from the *Proceedings of the Birmingham Natural History Society*.

Molecular percentage					Chemical Composition														
Current number / Group	A 13-a	T a b	D b a	M a	SiO_2	TiO_2	P_2O_5	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Sum	Rock Name	Locality
228	77.8	7.7	7.3	7.2	72.5	—	—	11.5	2.1	—	2.7	1.8	3.4	5.2	.7	99.1	Porphyritic felsite	Arran
229	76.7	9.8	6.7	6.8	71.9	—	—	15.6	—	.2	2.3	2.4	3.3	4.9	1.4	99.9	Dacite (glassy)	Cherty, Kasbeck
230	76.0	10.0	8.0	6.0	69.2	.4	—	14.3	2.1	2.3	1.3	3.2	3.3	3.5	.8	100.3	Tonalite	Meran
231	76.0	9.9	8.3	5.9	68.9	—	—	14.7	.9	2.3	1.6	3.0	3.7	2.8	1.6	99.4	Porphyry	Bohulibi
232	75.9	9.6	7.2	7.3	67.9	.9	.2	12.2	4.2	3.0	1.2	2.0	3.8	4.5	.7	100.5	Granite	Lovstakken
233	75.7	9.7	8.6	6.0	68.5	—	—	14.7	.4	3.3	1.4	2.8	2.9	4.1	2.3	100.5	Rhyolite	Sweden
234	75.6	10.3	7.1	7.0	66.6	—	—	15.1	.7	3.1	1.4	1.5	2.0	6.7	2.8	99.9	Porphyry	Münstertal
235	75.5	8.6	9.0	6.9	69.4	.2	—	12.8	1.1	2.6	.7	4.7	3.1	5.2	.3	100.2	Granite	Madeira, S. Amer.
236	74.7	9.7	8.7	6.9	64.6	.3	.1	13.6	1.2	1.2	.7	5.1	3.5	4.1	5.6	100.0	Quartz porphyry	Münster a/St.
237	74.4	9.3	8.7	7.6	65.0	.5	.1	13.7	.4	2.2	.8	4.4	3.7	4.8	4.3	100.1	Quartz porphyry	Saar-Nahe
238	74.3	11.1	7.4	7.2	65.7	.7	.3	15.3	2.5	1.6	1.6	2.7	3.6	4.6	.6	99.5	Quartz monzonite	Colorado
239	74.1	11.8	6.8	7.3	65.9	.4	—	16.8	1.6	1.2	1.5	2.7	4.7	3.2	1.4	99.4	Porphyry	Montana
240	73.7	12.7	5.6	8.0	65.6	.7	.2	18.7	1.3	1.3	1.0	2.3	5.6	3.7	.5	101.0	Plag. trachyte	R. Aar, Switz.
241	73.4	10.8	7.3	8.5	67.4	—	.1	15.9	1.4	1.1	1.4	3.5	6.4	2.6	.1	99.9	Aug. soda syenite	Minnesota
14 rocks Mean	75.3	10.1	7.6	7.0	67.8	.3	.1	14.6	1.4	1.8	1.4	3.0	3.8	4.3	1.6	100.0		
Group	14-a	a b b	a b															
242	78.2	7.9	3.8	10.1	70.3	—	—	6.3	9.2	1.4	.9	.8	7.7	2.5	.8	100.0	Pantellerite	Pantellaria
243	76.7	6.5	6.6	10.2	70.6	.1	—	8.6	2.5	6.3	.1	.6	6.8	4.5	.1	100.2	Rhyolitic obsidian	Br. E. Africa
244	76.2	9.3	4.8	9.7	68.8	—	—	11.3	4.9	4.3	.1	.5	6.1	4.4	.1	100.5	Liparite (4 and 5)	Somali Desert
245	75.7	8.2	6.5	9.6	69.1	—	—	10.5	3.6	6.4	.1	.4	6.2	4.3	—	100.6	Pantellerite	Oouache, E. Africa
246	75.5	9.4	5.1	10.0	67.5	—	—	9.7	7.4	2.2	.8	1.5	7.2	2.9	1.0	100.1	Pantellerite	Pantellaria
247	75.4	10.7	3.8	10.1	66.2	.2	—	14.2	3.1	1.7	.5	1.2	5.0	6.3	1.3	99.7	Granite	River Aar
248	75.4	6.1	7.5	11.0	68.8	—	—	5.9	5.8	5.3	.1	2.1	7.5	4.3	—	100.0	Pantellerite	Pantellaria
249	74.9	11.2	3.8	10.1	68.7	.3	—	17.1	.9	.4	.4	2.3	7.0	3.8	.6	101.5	Red granite	Osteroe, Norway
250	74.5	11.4	4.3	9.8	67.2	—	—	17.2	.8	—	—	3.6	4.7	6.7	—	100.3	Garnet granulite	Mexico
251	73.3	11.9	4.7	10.1	65.4	—	—	17.1	1.7	1.1	.4	2.5	4.8	6.9	1.8	101.7	Syenite	Monzoni
252	72.6	9.5	6.3	11.6	64.0	.8	—	10.4	6.3	4.2	.3	1.5	7.6	4.6	.2	100.0	Phonol. obsidian	Br. E. Africa
253	72.3	10.3	8.2	9.2	66.7	—	—	15.8	.7	.3	2.1	3.9	7.1	2.4	1.0	100.0	Dacite	Sumatra
254	72.2	10.4	7.7	9.9	63.0	—	—	13.4	3.5	5.3	.6	1.3	5.5	5.2	2.8	100.5	Quartz syenite	Fourche Mts.
13 rocks	74.8	9.5	5.6	10.1	67.4	.1	—	12.1	3.9	3.0	.5	1.7	6.4	4.5	.7	100.4		

Table Showing Names and Composition of Rocks of Groups 13 and 14.

Molecular percentage					Chemical Composition														
Current number / Group	A 15-a	T a b b	D b a	M	SiO_2	TiO_2	P_2O_5	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Sum	Rock Name	Locality
255	74.8	11.5	1.7	12.0	66.5	.7	—	16.3	2.0	.4	.2	.8	7.5	5.5	.5	100.5	Lestiwarite	Lougental
256	74.4	11.6	2.6	11.4	65.9	.5	—	16.0	2.6	1.8	.3	.3	7.4	4.7	.3	99.8	Alkali gneiss	Portugal
257	74.1	11.8	2.8	11.3	66.1	—	—	16.5	2.3	1.6	.2	.8	6.8	5.5	.6	100.4	Riebeck. trachyte	Berkum
258	73.5	13.0	2.4	11.1	64.3	—	—	17.5	3.1	1.3	.3	.6	7.3	4.3	1.0	99.7	Acmite trachyte	Montana
259	72.7	13.8	1.7	11.8	63.7	—	—	17.9	4.3	.5	.1	.8	7.2	5.2	.8	100.5	Sölvs bergite	Abyssinia
260	72.1	11.5	4.9	11.5	63.8	.7	.2	17.4	.1	1.5	.9	1.7	6.7	6.0	.4	99.3	Pyrox. syenite	Kuusamo, Finl.
261	72.0	12.2	4.3	11.5	64.0	.6	—	17.9	1.0	2.3	.6	1.0	6.7	6.1	1.2	101.4	Nordmarkite	Tonsenaas
262	71.2	13.3	4.2	11.3	62.2	—	.1	18.6	2.2	1.1	.7	1.6	7.6	3.9	1.6	99.5	Aemite trachyte	Montana
263	70.8	14.0	4.0	11.2	60.1	1.0	—	18.8	2.9	.9	1.0	1.1	4.6	8.1	2.0	100.6	Trachyte	Cape Vert
264	70.5	13.4	4.4	11.7	61.1	.3	—	13.8	2.0	3.1	.4	1.3	6.6	6.0	.8	100.0	Sölvs bergite	Massachusetts
265	70.4	14.5	3.7	11.4	60.1	1.2	.1	20.0	2.4	1.3	.8	.9	6.3	6.0	1.6	100.7	Foyaite	Arkansas
266	70.2	13.6	4.6	11.6	60.6	.7	.2	18.3	2.9	2.7	.5	1.0	6.7	5.7	.7	99.9	Syenite porphyry	Massachusetts
267	70.2	13.4	4.7	11.7	61.0	.5	—	18.5	2.1	.8	.9	1.9	7.3	4.8	3.1	101.3	Soda trachyte	Rhöngebirge
268	69.2	12.8	5.4	12.6	59.7	—	.1	17.0	3.2	1.3	.8	2.3	8.4	4.2	2.5	99.6	Syenitic trachyte	Montana
14 rocks Mean	71.8	12.9	3.7	11.6	62.7	.4	.1	17.8	2.4	1.5	.6	1.1	6.9	5.4	1.2	100.2		
Group	16-a	a b b	b b															
269	71.4	13.8	1.3	13.5	62.5	1.1	—	18.7	3.3	.5	.1	.5	11.8	.8	.7	100.0	Mariupolite	Sea of Azoff
270	70.8	13.1	2.6	13.5	61.8	.1	—	19.2	.7	1.7	.5	.2	7.9	6.7	(1.5)	100.3	Pegmatite	Isles de Los
271	69.1	13.8	3.3	13.8	57.6	.2	—	17.5	3.5	1.2	.2	1.4	5.8	9.2	3.2	99.9	Tinguaite	Montana
272	69.1	14.5	2.8	13.6	58.6	.2	—	19.6	2.2	.6	.4	1.2	8.4	5.3	2.9	99.7	Phonolite	Colorado
273	68.9	15.4	2.8	12.9	60.4	—	—	22.6	.4	2.3	.1	.3	8.5	4.8	.6	100.0	Elaeolite syenite	Maine
274	68.5	15.0	1.8	14.7	58.5	—	—	20.3	2.4	.6	—	.9	9.5	5.2	2.6	100.0	Phonolite	Dakota
275	68.5	15.3	1.3	14.9	59.5	(.2)	—	21.2	2.7	.5	.1	.5	10.7	3.9	(.7)	100.1	Alkali gneiss	Portugal
276	68.3	15.4	2.1	14.2	57.8	—	—	18.7	5.8	.4	—	1.3	9.4	4.5	1.5	99.4	Tinguaite	Abyssinia
277	68.1	14.1	3.4	14.4	57.9	—	—	19.1	2.5	—	1.1	1.2	6.6	9.2	2.4	100.0	Pumice	Krufter Ofen
278	65.9	15.4	2.7	16.0	56.2	.3	.1	21.4	2.0	.7	.2	1.5	10.5	5.7	1.0	99.9	Phonolite	New Mexico
279	65.7	14.9	3.4	16.0	54.9	.4	—	20.8	1.3	1.4	.4	1.0	9.0	7.3	2.6	99.7	Nephel. aplite	Cabo Frio, Brazil
11 rocks Mean	68.6	14.6	2.5	14.3	58.7	.2	—	19.9	2.4	.9	.3	.9	8.9	5.7	1.8	99.9		

Table Showing Names and Composition of Rocks of Groups 15 and 16.

Further there will be noticed in the diagram and in the tables a periodic rise of M from 4 to 4 groups. This gives us so many sets of more or less similar rock groups. The first group of each set has respectively the smallest percentage of monovalent bases, and the fourth a maximum. This is a very important and convenient feature. The latter groups, with numbers equal to multiples of four, represent the so-called alkali series of rocks. They include from group 16, 20 onward up to 60, a great many nepheline bearing rocks, also with leucite specially in group 48. The last four groups, from 61 to 64, are nearly devoid of alkalies, and are strongly magnesian, some purely periodotite rocks.

Also will be found herewith full details of one set of four groups, Nos. 13 to 16. They show the usual relation of the alkalies, increasing to a maximum in the last group, which has an abundance of nepheline bearing rocks. Group 13 has not a single example with nepheline. It will also be observed how regularly the means of divalent bases decrease from group 13 to 16.

As already explained our division is only founded on the sums of bases and not upon individual bases. We could therefore hardly expect much agreement of the latter. Notwithstanding this, individual bases fit generally very well within each group. In our example there is in group 14 more or less divergence of the tetravalent bases, and it might be suggested that we should sub-divide such a group according to the percentage of Fe_2O_3. There is, however, also much divergence of Fe_2O_3 in analyses of four rocks which occur in this group under the identical petrological name (Pantellerite). The divalent bases are of small amount in these groups. The monovalent bases are of much greater importance, and soda and potash agree individually. When they do not, but one of the two is preponderating, this indicates no petrological difference. We find elsewhere in other groups repeatedly names such as soda felsite, soda syenite, kali syenite, etc., which implies that the relative preponderance of either base cannot alter the petrological character of a rock

to a large extent if the petrological name remained the same.

It remains now to show how diagram No. 1 enables us to assign any rock to whatever group it belongs. We select for this purpose the following rock:

Phonolite trachyte. Hawaii. "Journal of Geology, 1904, p. 510. (Also Upsala Univ., p. 283.) Quantitative composition:—

SiO_2	TiO_2	P_2O_5	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	Cl	Total.
[illegible]	.37	.14	17.43	1.65	2.64	.32	.09	.85	8.28	5.63	.58	.09	99.93

Molecular percentage:—

[illegible]	.31	.07	11.51	.70	2·49	.30	.08	1.04	9.07	3.61			100.00
A = 70.60			T = 12.21		D = 4.81				M = 12.68				100.00

The following six constants are used for partition:—

1	2	3	4	5	6
D	T+D	T+D+M	D+M	T+M	M
4.5	18.7	29.4	17.2	24.9	12.7

Number of group	Formula	Molecular percentage A	T	D	M	Number of rocks
1	a a a a a a	85.2	8.4	3.1	3.3	18
2	a a a a a b	84.3	8.3	1.9	5.5	18
3	a a a a b a	82.0	9.8	1.9	6.3	24
4	a a a a b b	82.5	8.9	1.0	7.6	21
5	a a a b a a	80.8	8.5	5.1	5.6	16
6	a a a b a b	81.7	8.1	2.8	7.4	20
7	a a a b b a	80.4	9.5	2.5	7.6	27
8	a a a b b b	79.7	9.1	2.3	8.9	14
9	a a b a a a	78.1	10.2	6.1	5.6	16
10	a a b a a b	77.7	10.4	4.8	7.1	22
11	a a b a b a	76.5	11.9	3.8	7.8	18
12	a a b a b b	76.2	11.5	2.3	10.0	13
13	a a b b a a	75.3	10.1	7.6	7.0	14
14	a a b b a b	74.8	9.5	5.6	10.1	13
15	a a b b b a	71.8	12.9	3.7	11.6	14
16	a a b b b b	68.6	14.6	2.5	14.3	11
17	a b a a a a	73.4	11.6	10.9	4.1	14
18	a b a a a b	73.4	11.7	8.7	6.2	23
19	a b a a b a	71.4	14.0	7.5	7.1	15
20	a b a a b b	69.3	15.2	4.3	11.2	11
21	a b a b a a	69.6	11.7	13.3	5.4	30
22	a b a b a b	69.5	11.4	10.1	9.0	16
23	a b a b b a	68.8	12.7	10.2	8.3	11
24	a b a b b b	68.6	13.5	6.9	11.0	13
25	a b b a a a	66.2	14.1	14.9	4.8	19
26	a b b a a b	66.2	14.6	10.1	9.1	13
27	a b b a b a	65.6	15.4	7.3	11.7	19
28	a b b a b b	64.8	16.1	4.9	14.2	23
29	a b b b a a	64.9	13.2	16.9	5.0	22
30	a b b b a b	63.7	13.0	15.6	7.7	17
31	a b b b b a	61.6	15.3	13.7	9.4	13
32	a b b b b b	60.8	15.5	8.5	15.2	14

Number of group	Formula	Molecular percentage A	T	D	M	Number of rocks
33	b a a a a a	63.0	12.6	21.0	3.4	16
34	b a a a a b	63.4	11.7	19.8	5.1	19
35	b a a a b a	59.7	15.6	20.2	4.5	13
36	b a a a b b	59.5	14.5	19.0	7.0	12
37	b a a b a a	59.2	10.5	26.5	3.8	17
38	b a a b a b	59.7	9.7	25.2	5.4	15
39	b a a b b a	58.8	12.6	24.0	4.6	15
40	b a a b b b	59.6	10.8	21.9	7.7	12
41	b a b a a a	56.3	13.2	27.0	3.5	24
42	b a b a a b	55.9	13.1	25.9	5.1	14
43	b a b a b a	55.2	16.1	23.6	5.1	16
44	b a b a b b	55.7	14.2	21.9	8.2	16
45	b a b b a a	55.5	10.4	30.8	3.3	23
46	b a b b a b	54.5	10.3	29.9	5.3	20
47	b a b b b a	53.5	13.0	27.7	5.8	15
48	b a b b b b	52.5	13.1	25.0	9.4	15
49	b b a a a a	52.8	11.3	34.2	1.7	11
50	b b a a a b	51.9	11.0	33.6	3.5	17
51	b b a a b a	52.0	15.1	30.4	2.5	11
52	b b a a b b	50.1	14.0	31.4	4.5	16
53	b b a b a a	49.2	6.6	43.2	1.0	11
54	b b a b a b	50.0	7.6	38.8	3.6	8
55	b b a b b a	48.5	10.9	37.5	3.1	14
56	b b a b b b	48.0	10.8	35.8	5.4	12
57	b b b a a a	44.8	9.6	44.1	1.5	11
58	b b b a a b	44.9	9.2	42.0	3 9	13
59	b b b a b a	43.9	14.4	38.9	2.8	10
60	b b b a b b	44.3	12.5	37.2	6.0	13
61	b b b b a a	38.0	3.4	58.6	.0	14
62	b b b b a b	39.7	4.4	54.8	1.1	7
63	b b b b b a	41.0	7.4	50.0	1.6	10
64	b b b b b b	41.5	7.7	46.1	4.7	8
Mean		64.22	11.60	17.83	6.35	

One Thousand Rocks Examined and Classified According to Their Contents of Trivalent (*T*) Divalent (*D*) and Monovalent (*M*) Bases.

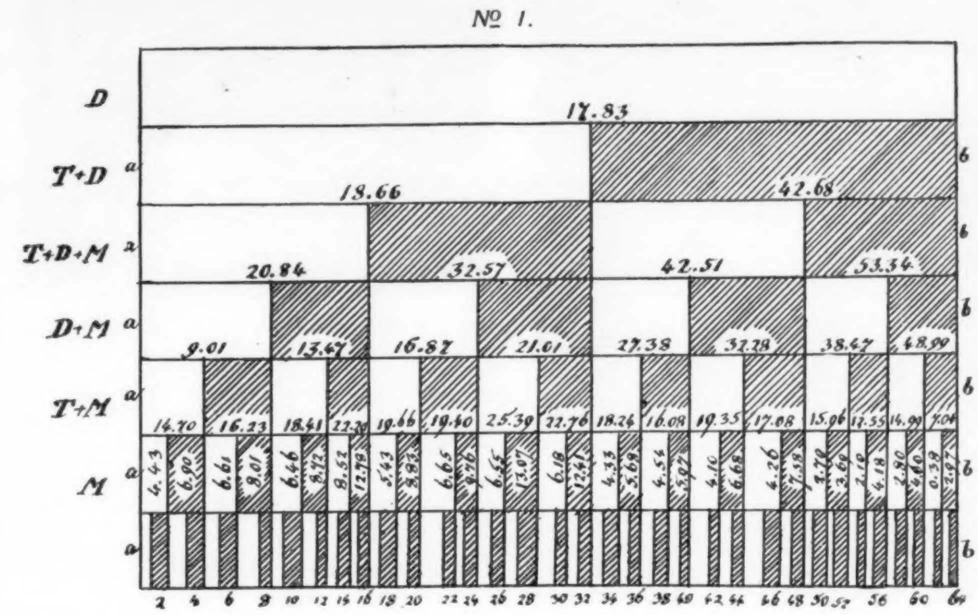


Diagram of the Classification of Rocks According to Their Contents of Trivalent (*T*), Divalent (*D*) and Monovalent (*M*) Bases.

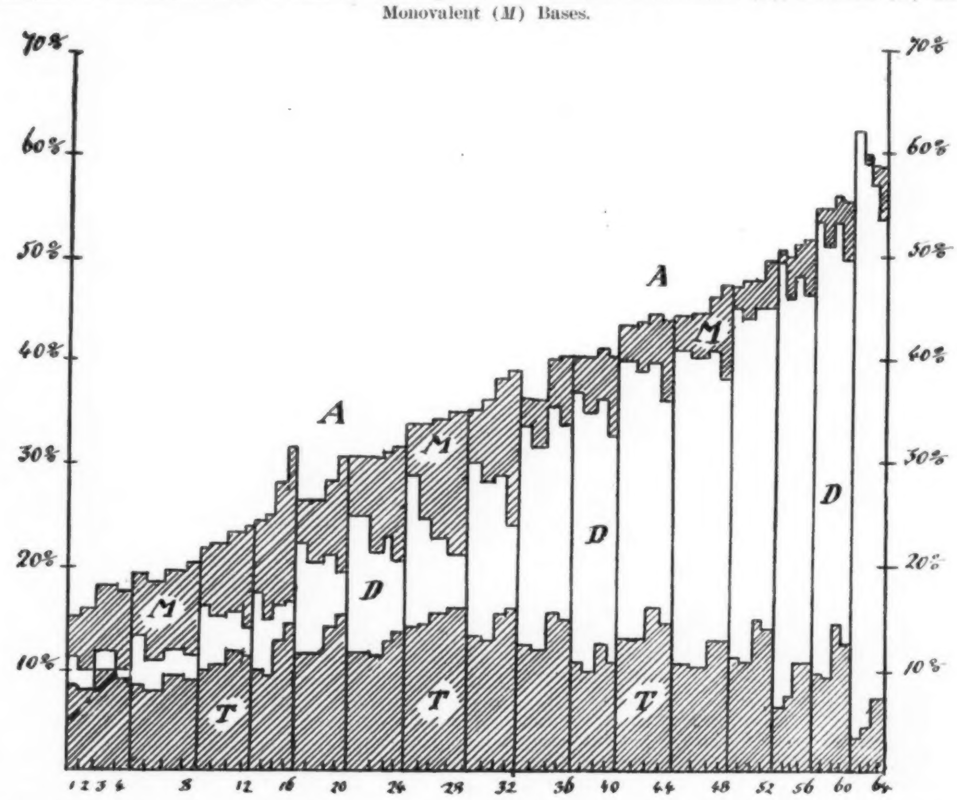


Diagram Showing the Number of Rocks (as Measured by Abscissæ) Which Fall Into Each of the Sixty-four Groups, and Their Composition. This is a Graphic Representation of the Tables Adjoining.

With these constants at our disposal, diagram No. 1 enables us to determine the group in a very short time. We proceed from row to row ascertaining if our figure for D, T + D, etc., is smaller or larger than the figure on the diagram, in the former case giving the letter "a," in the second case "b." According to the letter "a" or "b" we successively move to the left to a blank rectangle (pigeon-hole) or to the right to a shaded rectangle. We thus arrive at the formula "a a b b b a," and our rock belongs to group 15. As our value of M happens to be very close to the respective constant 12.78 in the sixth row, the rock approaches the boundary of group 16.

According to the descending order of A in the table page 330 it falls between the rocks number 263 and 264, and we find it closely related to these neighbors.

In conclusion I may remark again on the ease with which a group for a rock is found by means of diagram No. 1. Once the molecular percentage has been obtained or calculated, it takes less than a minute to complete the operation. We notice that this resembles the simple method of finding a word in a dictionary. As we find a word by taking up in order one consecutive letter after the other in a dictionary, so we find our group by selecting either the letter "a" or the letter "b" six times in succession.

Rat-proof Buildings

The recent elemental catastrophes—the cyclones in the Middle West, and the floods in that vast region watered by the Ohio—have destroyed many hundreds of buildings. Here, out of misfortunate much good should come. A timely appeal for the rat-proofing of dwellings and other buildings at present existing, under construction or in contemplation comes from the United States Public Health Service. Those about to erect a new building or repair an old one, whether of frame, brick, rock, concrete or other construction, may learn from Dr. Simpson's paper what sanitary and economic benefits are to be derived from permanent rat-proofing; and measures to such ends should be demanded by prospective owners as a part of building contracts. The rat is far too prolific to be exterminated by such agencies as traps, poisons, lethal gases and the like; these may reduce the numbers of the rodents, but if there is food within reach, the surviving rats will have more to eat proportionally, and procreation will be stimulated the more. Rat extermination can be effective only by separating that creature from its provender. Dr. Simpson's paper appears to contain all necessary information to this end, so far as relates to buildings. Those already erected can be rat-proofed by the closure of all natural or accidental openings; by being remodeled with material impervious to rats; by the removal of structures which will give refuge to rats, and by the protection or removal of foods which rats will eat.—*Journal of the American Medical Association.*

Fig. 1.—Telephoto Night View. "Old Faithful." Spatter Phase.

Fig. 2.—Telephoto Night View. "Old Faithful." Dome Phase.

The Lava Fountains of Kilauea*

Observations by Telephotography

By Frank A. Perret

Fig. 3.—Telephoto Day View. "Old Faithful." Dome Phase.

THE observer, standing upon the brink of Halemaumau, looks down into a pit-crater with the vertical, stratified walls characteristic of the type and with, possibly, a "black ledge" forming a shelf at some distance below the edge and marking a former level of the lava column. If this is still receding, a talus of broken fragments of the ledge—fallen for want of support from below—softens the lower angle, but if, on the contrary, the lava has been rising for some time, the crater floor will extend as an apparently almost flat surface directly to the vertical walls of the pit. In what may be considered the normal state of activity this crater floor consists of a central liquid portion—the lava lake—and a surrounding "shore" of solidified lava chilled by conduction to the crater walls, and growing vertically with the rising lake by overflows from its surface. The liquid portion is maintained at a higher level than the surrounding solid surface by a retaining rim which is formed by accretion during the various oscillatory movements of the constantly agitated liquid and by the spattering of peripheral fountains.

The condition of the crater floor, as it appeared in July, 1911, is shown in Fig. 5, and upon the lake may be seen one of the so-called "Floating Islands."

The form of the true crater—as seen when drained of its contents by a subterranean, lateral outflow of lava—is that of a basin over three hundred meters in depth terminating below in a large, well-like opening more than a hundred and twenty meters in diameter, as shown in a sectional design by the survey of E. D. Baldwin in August, 1902.

In times of abnormal activity there is re-fusion of solidified material and a wholly liquid floor (lake) extending to the sides of the pit with a surface practically covered with fountains. Occasionally the lava column fills the basin and overflows into the main crater of Kilauea, thus adding to the flat cone which is gradually filling that greater pit.

Let us now observe the lava lake under normal conditions, as shown in Fig. 5. The surface material is moving majestically from some point, often under an overhanging bank where it is rising from below, to one or more localities—it may be at the opposite end of the lake—where it is evidently descending. Under the bank it is seen to be brightly incandescent, but, upon exposure, there forms upon its surface a film of a satiny and often iridescent sheen greatly resembling in appearance the oxidized surface of molten metal in a plumber's solder pot. As the flow is divergent, this skin is pulled apart, forming a series of radiating "bright lines" which, if the activity is moderate, often constitute, at night, the only luminous portion of the surface, exception taken of the fountains. The film gradually thickens by accretion from below and changes from a tough, flexible skin to a true crust which is brittle and cracks under unequal pressure.

* Reproduced from the *American Journal of Science.*

Suddenly a large, circular area of the lake surface, in the center of which a fountain is to appear, is strongly agitated as though a violent up-thrust had been given from below, and in a few seconds there rises through the surface skin a beautiful dome-topped column of perfectly liquid lava—bright orange-yellow in clear sunlight—

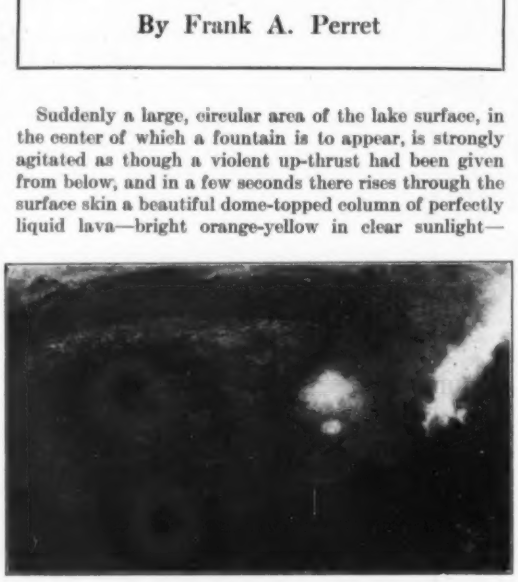


Fig. 4.—Cloud of Burned Gases from a Lava Fountain (Seen Over ×).

bursting upward in a shower of fiery drops or boiling, dome-shaped, for a few moments and then subsiding into the lake amid surging waves as the parted surface-lavas close over the spot, where smaller jets continue spouting and a general commotion prevails for some time. Nor even so is the phenomenon at an end, for the cooling of the fountain lava, and the reduction of its volume by contact with air and the loss of its gases, give to it a greater density, and this, together with the acquired momentum of its subsidence, favors rapid sinking and a local void with a lower surface level. The result of this is a general in-surging of surface lava from all sides and a considerable down-flow where the fountain lava sank. In the case of a large fountain appearing at frequent intervals in the same place there may be a practically continuous surging thereto of surface lava whose down-flow will then form a part of the lake's circulatory system. This is especially the case with the peripheral fountains, but the subject of circulation is to be treated specifically in a future paper and this phase is here referred to merely as a direct effect of fountain action.

The noble proportions of the surroundings and the considerable distance from the eye of the observer unite in giving an impression of the size of the fountains which is far below the reality. For visual observation a good glass is essential, but the rapidity of motion renders photography a more satisfactory means of study, providing an image of sufficient size can be obtained with a short exposure. For this purpose the writer employed a Zeiss "Magnar" telephoto equipment having an equivalent focal length of 80 centimeters with a working aperture of F. 10. At an average distance of 200 meters the photographic images of the fountain domes were 5 centimeters in breadth, which gives to the fountains a diameter of fully 12 meters.

The aperture permitted of very short daylight exposures, and at night an exposure of ¼ second was sufficient, which, if the moment were well chosen, resulted in satisfactory definition.

By this means we distinguish, in the average large fountain, three principal periods which may be designated as, 1, the Spatter Phase (Fig. 1); 2, the Dome Phase (Figs. 2 and 3); and 3, the Subsidence Phase (Fig. 6). Not all the fountains show both the spatter and dome phases, many simply doming up without a drop of lava being thrown off, while others are so scattered that scarcely the semblance of a dome can be observed, but the normal Kilauea fountain shows all three. The spatter phase of these fountains forms the source of the well-known filamentary lava—"Pele's Hair"—the drops thrown from the fountain spinning out glassy threads which are wind-borne to a distance and take the place, as ejectamenta, of the scoriæ, lapilli, and ash of more viscous lavas.

When a fountain boils up, bringing highly incandescent lava into contact with the air, the cooling of the surface takes place with extraordinary rapidity, the bright orange dome becoming covered almost instantly with a brown skin which the boiling movement converts into a network of dark lines, as shown in Fig. 3. The reader must here be reminded that these lines, as well as the surface skin of the lake, appear lighter in the daylight photograph than the glowing lava of the fountain dome.

Regarding the dynamics of these fountains of lava there has existed a great diversity of opinion. Wm. Lowthian Green[1] held that the action is purely hydrostatic—the forcing up from below of a simple liquid—and even included in this hypothesis the greater occasional fountains of the Mauna Loa crater, over 4,000 meters above sea level. Daly[2] attributes the phenomenon to the rising of a mass of lava lighter than the rest by reason of greater vesiculation, and which, he says, is "best explained, in part, on the principle illustrated in the upspringing of a log of light wood freed at the bottom of a lake. Through

[1] "Vestiges of the Molten Globe," Part II. Honolulu, 1887.

[2] Reginald A. Daly, "The Nature of Volcanic Action;" Proc. Amer. Acad. Sci., vol. xlvii, No. 3, June, 1911.

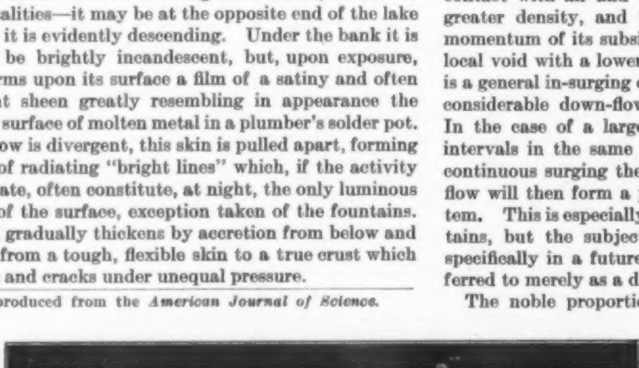


Fig. 5.—Lava Lake, Halemaumau. From East Brink, July, 1911.

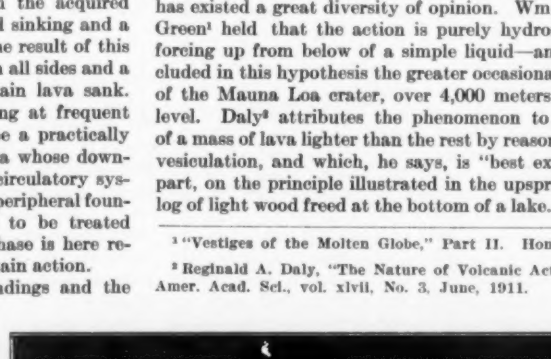


Fig. 6.—Telephoto Night View. "Old Faithful." Subsidence Phase.

its momentum the log may jump clear out of the lake."

The present writer goes much further than this in the direction of a purely gaseous hypothesis, the principal reasons for which are advanced below.

It is, first of all, necessary to realize that, in the active portion of the lake, we have a material which is physically very different from the ordinary conception of lava, and this difference lies principally in its marvelous, its superlative, mobility. Now, that a heavy liquid should be mobile need not cause surprise, as this may be done to its molecular formation—mercury has weight yet it is known as quicksilver. But something more than this is required to account for the mobility of the active lake lava, which is of a different sort from that of mercury, and this is to be found, I believe, in its high gas content. The lava is so charged with gas that this is constantly being evolved intermolecularly and expanded upon relief of pressure, and the liquid, while still heavy, acquires some of the peculiarly mobile yet momentum-damping qualities of *foam*. A piece of rock, tumbling over the talus and reaching the shore with just sufficient momentum to topple over into the lake from a height of but a few centimeters, sinks with apparently less resistance than in water and the liquid closes over it without a splash. Daly's quaint statement regarding the flow of pahoehoe[3] might well, I believe, be applied to this material—it "moves, as it were, on molecular and vesicular 'ball-bearings.'"

As a result of this condition large gas bubbles may rise rapidly through the liquid and produce fountains, and yet escape without visible commotion—excepting in the spatter phase—other than the boiling movement of the dome, and, as the gas is invisible, many observers have asserted its non-existence. Fortunately, however, an observable phenomenon enables us to prove our contention—the gas, on coming in contact with the atmosphere, *burns*. The flames, which have frequently been seen issuing from spatter cones on the shore or from blowholes in spatter grottoes at the lake margin, are generally described as having a blue or green color, but we must here guard against effects complementary to the glare of the lava. A stream at Etna emitted vapors which were colorless by day but, as twilight came on, the lava glowed strongly red and the vapors appeared green, while at night their tint was violet against the golden yellow glare.

The flames are faintly luminous and are only visible against a dark background. In fountains with a pronounced spatter phase the flame is lost to sight in the brightness of the scattering drops, but in fountains limited to the dome formation (Fig. 2) the flame may always be seen (but not photographed) issuing from the top of the dome as a flash of brief duration. During three months of continuous observation comprising a rising, stationary, and falling lava level, every fountain dome produced its flame, and the many visitors, to whom it was pointed out, had no great difficulty in observing the phenomenon.

But here again we are fortunate in being able to appeal to the photographic record, for, if the gases which leap from the fountains are invisible by daylight, the products of their combustion are not so, but form a transparent cloud of light blue vapor—also faintly visible—but which, by reason of its highly actinic color, is easily photographed. In Fig. 4, above the mark × may be seen the round area of a subsiding fountain dome and over it, the cloud of burnt gases, undisturbed, in this case, by the wind which frequently prevents the photographing of this phase of the gaseous outburst.

The emission of gas is also constantly, if quietly, going on over the entire surface of the lake. With a powerful binocular the writer was able to observe that every one of the innumerable small openings in the crust had its own little blowpipe jet of burning gas. The pressure was high and the jets of flame, inclined in all directions by the obliquity of the holes, were straight, pointed and perfectly motionless. Fissures in the crust produce broad sheets of flame as steady as the pointed jets.

On the subject of the chemical composition of this gas the writer prefers not to enter at present. The research work now being carried on at Kilauea will soon result in the complete analysis of the gases collected over the boiling lava before burning in air, and until this is forthcoming it is advisable to be patient. The present paper is intended to form a contribution to the physical, and not the chemical, study of the lava fountains. It should be stated, however, that, in all my experience with Italian volcanoes, wherever fresh, active lava has first issued into contact with the atmosphere the gases have burned with a flame identical in appearance with those at Kilauea. At Etna in 1910 a continuous jet had a height of from 10 to 20 meters and was blown in all directions by the wind.

But these gases which issue from the liquid lava of a volcano are not, in the writer's opinion, to be considered as juvenile gas in its primal state but that which, expanded into and worked over with the lava in the volcanic edifice, is subjected to the action of air, water and oxidizing and transforming processes of the most complicated kind resulting in the formation of those oxidized and hydrated compounds of sulphur, carbon, chlorine, etc., which constitute the gaseous emanation of ordinary volcanic activity. But the pure magmatic emanation, i. e. the *paroxysmal* gases of a great eruption which, after the expulsion of the liquid lava in the throat of the volcano, issue directly from the depths in a cloud of magmatic ash, are sweet and clean as the air itself and appear to have the same composition. On two occasions at Vesuvius in 1906 and once at Stromboli in 1912 the writer was enveloped in the cloud of gas and ash at distances of from 1,500 meters to only 250 meters from the crater during paroxysmal activity. The darkness was absolute from the density of the cloud and the condition continued, in one case, full twenty minutes; yet, not only was there no difficulty in breathing but no trace of HCl, SO_2, H_2S, etc., could be perceived by one accustomed to detecting these in small amounts.

Returning to the Kilauea lake we see that very small fountains play over all portions of the surface where the resistance of the crust is low, as in the "bright lines." They are evidently caused by the coalescence, below the surface, of small gas vesicles into larger ones with greater tension and ascensional power. This action is automatic and small quantities of the active lava, isolated from the lake, continue to show all its phenomena until liquidity ceases from loss of heat, even the pahoehoe streams which overflow the rim of the lake continuing to show tiny fountains upon their surface until it cools over.

The so-called "traveling fountains" are due to the circulation of the lava, in spite of which three or four large fountains maintain a remarkable constancy of position in the area lying approximately over the Halemaumau conduit, among which the one known as "Old Faithful" is pre-eminent. It would seem that the gas bubbles, rising through the liquid mass, create a path of less resistance which tends to be perpetuated by further emission. A striking example of this was seen at Etna in 1910, where the loci of the explosions were continued as the stream flowed downward (Fig. 7).

Fig. 7.—Etna, 1910. Permanence of Gas Sources on Flowing Lava.

The writer holds that the fountains of Kilauea are caused by the rise and expansion of large bubbles of gas in a hypermobile lava. The jets of incandescent, liquid lava at Stromboli, Vesuvius, Etna, etc.,[4] are true lava fountains in which the spatter phase prevails because of the somewhat greater viscosity of the lava.

That some forms of volcanic action are quiet and non-explosive need not signify that they are non-gaseous. Eruption is, fundamentally, not explosion but emission of gas. Explosion occurs when the emission is obstructed and the gases have acquired sufficient tension to remove the obstruction. The writer believes that the great outpourings of basalt during fissure eruptions were accompanied by the emission of enormous quantities of gas.

[3] Op. cit., p. 108.

[4] An example may be seen over the crater in Fig. 7.

Propagation of High-Frequency Electric Waves Along Wires—II*

Advantages and Limitations of the System for Practical Operation

By John Stone Stone

Concluded from Scientific American Supplement No. 1950, page 311, May 17, 1913

A most important feature of both existing telegraphy and telephony is the centralization of the current supply and this feature is, fortunately, most easily realized in the new high-frequency telegraphy and telephony. It brings the high-frequency generators, whether they be high-frequency dynamos or oscillators, under the constant supervision and care of a trained man at the central office. The author has devised several ways in which the centralization of the energy may be practically accomplished. Only two of these ways need be referred to here. In the first, the high-frequency generators are connected in series in the circuit at the central office, and each is shunted by a number of branch resonant circuits. Each branch circuit is separately made resonant to a different one of the several frequencies of the currents used on the line other than that of the current developed by the generator it shunts. Another practical mode of centralizing the energy is shown in Fig. 7. The several generators, each in a local circuit tuned to its own frequency, are brought into inductive relation with a transformer secondary in series or in parallel with the telephone or telegraph circuit. The generators in the centralized energy system develop higher potentials than those designed to be used at sub-stations, or else the voltage of the generator is stepped up to the desired voltage.

In this paper no more than a passing reference has been made to the extremely important fact that multiplex high-frequency telegraph and telephone systems may be superposed on existing telegraph and telephone circuits without bringing about the least mutual interference between the old and the new systems, and this subject and its important practical aspects will not be further dwelt upon here because it has received a fairly complete exposition at the hands of Maj. George O. Squier, both in his patents and in his paper before the American Institute of Electrical Engineers.[5] Only such features of high-frequency telegraphy and telephony as have not elsewhere been adequately brought out or discussed so as to make clear their bearing upon the future practical application of the propagation of high-frequency currents or electric waves along wires will be dwelt upon.

There is an element of every system of transmitting intelligence, namely, the *call* and its allied automatic circuit control mechanisms, which has been highly elaborated, particularly in the older system of telephony. In the new high-frequency telegraphy or telephony, when used by itself, either as a simplex or multiplex, the *call* and automatic circuit control mechanism system generally need not be different from that in use to-day in the older systems, but in lieu of this the call may be effected by a very flexible system of selective low-frequency electric signalling over the same line. In this selective signalling system, each of a number of stations on the same line is called by the use of a low-frequency alternating current of a different frequency thrown on the line, and the selection of the signalling current at the different stations called is effected by electrically resonant local circuits or branches at these stations, each attuned to the frequency of the particular alternating signalling current by which it is intended to be operated.

When the high-frequency system is used in conjunction with, and on the same line as, the existing system of telegraphy and telephony, a separate high-frequency call or signalling system is preferably used. This call or signalling system is identical with the high-frequency telegraph system itself, except that it operates a local battery call device, such as a vibrator bell or buzzer, instead of operating a telephone receiver, and for this reason it is necessary that the calling current manifest more energy at a distant station than does the corres-

* Reproduced from the *Journal* of the Franklin Institute.

[5] See also Scientific American, January 21st, 1911, p. 59.

ponding high-frequency telegraph or telephone current under similar conditions. To accomplish this purpose a relay of great sensibility and extreme sluggishness of action is used in conjunction with a rectifier in a tuned local circuit at the receiver station. To call the station, a high-frequency current of the same frequency as that to which the local circuit at the receiver containing the rectifier and relay is attuned is thrown upon the line and maintained thereon until the sluggish relay has time to respond and close the local battery circuit containing the vibrator bell or buzzer.

The relay which the author has found to best meet this requirement of great sensibility through sluggishness of action, is of the Weston moving coil type. It has very high resistance and has an electro-magnet producing an extremely intense field in place of the permanent magnet of the usual Weston instrument. This method of effecting a call, which involves the integrating of the energy of the received current over a relatively long period of time by the use of a receiving device, extremely sluggish in its response, is imported from radio-telegraphy, where it was first used by the German company, the Gesellschaft für Drahtlose Telegraphie of Berlin. Experiments have not yet, so far as the author is aware, shown whether it is possible to operate this selective call over as great a length of line as it is possible to telephone or to telegraph at ordinary speed with a current of the same frequency, but the promise is good.

A great advantage enjoyed by the new high-frequency telephone system over the existing system is in the important particular of *distortion*. In the existing system of telephony, the currents as they are propagated along the line suffer a continual *attenuation* or a loss of amplitude, an effect to be minimized as far as possible. Still more harmful, however, in general, is the distortion of the telephone current which it engenders through the fact that the component alternating currents of different frequencies which make up the telephone current are unequally attenuated. Usually, therefore, long before a telephone current has been attenuated to a point at which it is too feeble to be of use, it has been so far distorted as to be incapable of producing intelligible speech at the receiver. In other words, considerably more attenuation than is now tolerable could be permitted in telephone systems were it not for the distortion that usually accompanies it.

In the new high-frequency system of telephony, *attenuation, though greater than in the older system, brings with it no distortion whatever.* There is, in fact, in the transmission of a given message, but a single frequency of current involved, and therefore no unequal attenuation of components of different frequencies and no distortion.

Another signal advantage of the new high-frequency telephone system over the existing system lies in the *silent line*[9] which it enjoys. Were it not for the noisiness of the average telephone line in the existing system, telephone receivers of far greater sensibility could be used with advantage, and, furthermore, a much fainter transmitted speech would be easily understood and even prove more acceptable to the telephone subscriber than the louder transmission does on the average telephone line to-day. In the new telephone system, telephone receivers of several thousand ohms are used, having correspondingly greater sensibility than the low-resistance receivers in use in the existing telephone system.[10] Moreover, transmitted speech which is so faint that it would be completely swamped and ineffective on even a moderately noisy line is heard and understood against a background, as it were, of absolute silence.

The absence of distortion and the silent line of the new telephony remove the chief obstacle to the use of the telephonic amplifier at or near the receiving end of a long line to compensate for the weakening effects of attenuation on the current. In this connection it is to be noted that in the existing system, when a telephone current has been sufficiently attenuated in passing over a long line to require amplification, it is also so distorted, and so intermixed and confused with *line noise currents* which the amplifier would bring out or intensify that a telephone relay for amplification purposes, no matter how perfect it might be in itself, has by some engineers long been regarded as of little value. Another influence which has militated against the utility of amplifiers in telephony in the past is that for two-way transmission the amplifier has a persistent tendency to sing to itself in much the same manner and for much the same reason that a telephone receiver sings to its transmitter when it is held in front of the mouthpiece of the latter if the efficiency of the combination is sufficiently great. The greater the amplifying power of the telephone relay, the more persistent this tendency to sing to itself, and to overcome it resort has been had to so-called *telephone relay circuits*, which seek to exclude the current developed by the transmitter element of the amplifier from its receiver element. These *telephone relay circuits* are essentially

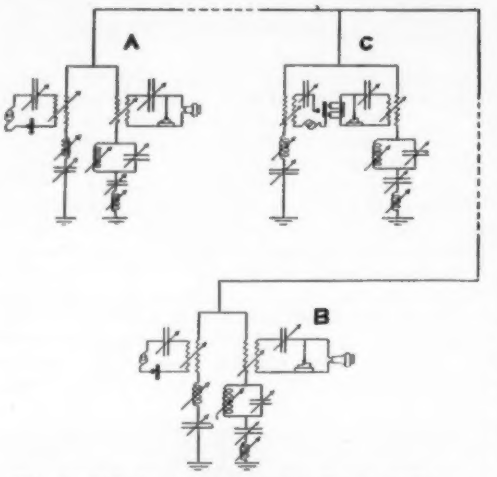


Fig. 5.—Telephone Amplifier for Two-way Transmission.

induction balances in which the transmitter and receiver elements of the amplifier are in conjugate branches and the line wire forms one or more arms of the balance. In the case of an amplifier that really amplifies, the least change in the line conditions upsets the balance sufficiently to set the amplifier singing to itself and, even in the case of constant attention on the part of a skilled operator, this, at least temporarily, causes an interruption of service. In high-frequency telephony no such restraining conditions operate against the use of amplifiers for two-way transmission, since the current from the transmitter element and that directed to the receiver element are of different frequencies and the receiver element is placed in a branch or local circuit adjusted to exclude the current from the transmitter element, irrespective of the conditions of the line.

Fig. 5 shows a typical arrangement of a telephone amplifier adapted for two-way transmission in a system of high-frequency telephony. In it the transmitters and receivers are the same as those already shown and described, and at the amplifier station *C*, the transmitter and receiver elements are the same as the transmitters and receivers shown at *A* and *B*. In such a system the

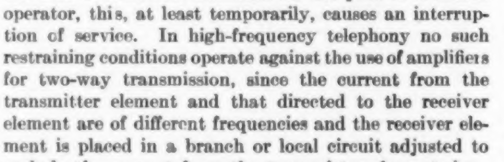


Fig. 7.—Centralizing the Energy of the System.

transmitters at both stations *A* and *B* develop currents of the same frequency, this frequency being that of the current to which the receiver element of the amplifier is responsive, while the receivers at both stations *A* and *B* are selective of currents of another frequency, this second frequency being that of the current developed by the transmitter element of the amplifier.

The most serious obstacle to the successful use of the new high-frequency telegraph and telephone is undoubtedly the excessive attenuation or progressive weakening of its current as it flows along the line, particularly in cable circuits, and unless countervailing or remedial conditions can be found, the use of these high-frequency systems must be very materially restricted through being confined to relatively short lines.

The average frequency of the ordinary telephone current is about 800 cycles per second, but the highest harmonics range between 4,000 and 5,000 cycles, and it has been found that it is necessary, for the complete clearness of articulation of the transmitted speech, to conserve harmonics up to about 1,500 cycles.[11] The highest useful frequency in ordinary telephony is, therefore, about one tenth of the lowest frequency which Major Squier's experiments seem to indicate as possibly practicable for the new telephony, and about one seventieth of the highest frequency regarded as practicable by Major Squier for the new system. In making comparisons of the attenuation in the old and new systems these ratios should be borne in mind.

Since in the new system of telephony a greater current is thrown on the line than in the existing system, and since, further, a receiver of very much greater sensibility is employed, evidently a considerably greater attenuation of the current of the system is permissible than could be tolerated in the old system, and when, further, the absence of noise, the absence of *distortion*, the absence of *side tone*, and the absence of reflection of energy from the receiving end of the line are taken into consideration, it seems conservative to estimate that the maximum practical permissible *attenuation length* in the new telephony is 6.9, as compared with 4.6 in the existing system. An example of how this affects the range of transmission of the new system may perhaps be best gathered from a concrete example, and for this purpose an open-wire telephone line construction will be chosen which is of a type in most common use in the United States for transmission to distances up to 450 miles. This line is of the two-wire or so-called *metallic circuit* type, in which the wires are of hard-drawn copper 0.104 inch in diameter, and are separated on the cross-arms by a distance of 12 inches. Assuming for this line an insulation resistance of one megohm per mile, the ratio of the attenuation constant for currents of 1,500 and 100,000 cycles per second, respectively, is very closely 3, and, other things being equal, this would mean that the new system could not be used to transmit speech over more than 150 miles of such a circuit. On the basis of an attenuation length of 6.9, however, it would seem that practical transmission of speech by the new system could be had over a length of 225 miles of this circuit. The disparity between the distances to which unaided transmission may be had by the existing and the new system is somewhat greater in the case of open-wire circuits of larger than of smaller wire, and this disparity is, in general, greater in the case of cable circuits than in the case of open-wire circuits.

Even if no effective means be found to extend the range of the new high-frequency telephony, few will seriously contend that there is no practical gain to be realized in making use of a 450-mile circuit as it is at present used and further simultaneously employing it in two sections, each 225 miles in length, for the multiple transmission of, say, forty-two messages, twenty-one on each section.[12]

In the existing system of telephony, when it is necessary to diminish the attenuation on a line without increasing the size of the wire used or the separation between the wires, resort is had to methods of diminishing the attenuation constant by adding inductance to the line without producing a proportionate increase in its resistance. A circuit so treated is said to be "loaded" with inductance and is called a "loaded" circuit. Two methods have been used. In one the added inductance is uniformly distributed along the line and is secured by wrapping the insulated wire with a winding of iron wire. This method of loading cables has found favor in Germany and Holland. In England, France, and the United States the only method of loading telephone lines used is by means of a system variously ascribed to M. I. Pupin,[13] to G. A. Campbell,[14] to Sylvanus P. Thompson,[15] and last, but by no means least, to A. Vaschy.[16] In this system of loading lines inductance coils having time constants $\frac{L_1}{R_1}$ larger than the time constant per unit length of the unloaded line $\frac{L}{R}$ are introduced in the circuit at equal intervals, small compared to one half the wave length of the highest frequency component of the telephone current to be conserved in transmission.

The method of loading lines by uniformly distributed added ferric inductance would seem, on its face, to be available for the high-frequency systems of telegraphy and telephony, but it suffers from several disadvantages. In the first place, it is ill adapted for open-wire circuits; in the second place, it renders cables excessively heavy and bulky; in the third place, it is impossible to prede-

[9] The receivers in the new system are not only unaffected by the usual *cross talk* or induction between adjacent telephone circuits, and by inductive disturbances generally, that so often cause confusing noises in the receivers of the existing telephone system, but they are, moreover, mute to their own transmitters. In other words, there is in the new system no so-called *side tone*, and the user of the system speaks as loudly as he pleases into his transmitter without deafening himself by hearing the sound of his own voice rasping in his own telephone receiver, as so often happens in the existing system.

[10] The sensitiveness of a telephone receiver is approximately proportional to the square root of the resistance of its windings. In connection with the centralized energy systems in the United States, telephone receivers of from 20 to 60 ohms are used. The telephone receivers employed in the new high-frequency system are of 2,000 ohms resistance.

[11] See B. S. Cohen, *Phil. Mag.*, September, 1908; also *Proc. Phys. Soc. London*, vol. xxi.

[12] The number of stations which can be used in any given case is the nearest whole number to

$$1 + \frac{0.82393}{\log_{10}(1 + \triangle)}$$

where $100\triangle$ is the least percentage difference permissible between frequencies. The number of stations assumed in the above example is on the basis of a 10 per cent difference between the frequencies.

[13] "Propagation of Long Electrical Wires," by M. I. Pupin. Trans. A.I.E.E., March, 1899. "Wave Transmission Over Non-uniform Cables and Long-distance Air Lines," by M. I. Pupin. Trans. A.I.E.E., May, 1900.

[14] Records for Pupin & Campbell in interference in the U. S. Patent Office No. 20,699, also *Phil. Mag.*, vol. v, p. 319, March, 1903.

[15] "Ocean Telephony," by S. P. Thompson, *Trans. Int. Elect. Congress*, 1893; also English Patents Nos. 13,064 and 15,217 of 1893.

[16] A. Vaschy's numerous mathematical discussions bearing upon this subject are to be found in *Annales Telegraphiques* 1888-'89, in his *Electricité et Magnetisme*, and in *L'Eclairage Electrique* 1897, and elsewhere.

termine the attenuation constant of such a circuit, and in the fourth place, there is evidence tending to show that when a cable so loaded is used in connection with high-frequency currents the dissipation of energy due to hysteresis in the iron wrapping will largely, if not wholly, compensate the beneficial effects of the increased inductance of the circuit.[17]

The use of the second system of loading lines would seem to be precluded by the expense involved. The number of loading coils used would have to be about 70 times as great for the 100,000 frequency current of the new system as is now used on the basis of approximately 4.5 coils per wave length for a current of 1,500 frequency.

Since, for equal degree of loading of the line in the new and the old systems, the inductance of the coils used for currents of 100,000 frequency would be but one seventieth of that of the coils used in the old system, it might at first glance seem as if the coils would be correspondingly cheaper, and that, consequently, the disparity in the cost of loading the line in the two systems would result chiefly from the greater cost of labor in installing the more numerous coils in the case of the new system. But this conclusion is not justified, because the time constant of the coils in the case of the new system must be as great as in the older system, and the bulk, weight, and cost of coils depend far more on their time constants than on their inductances.

So far from these systems of loading lines with inductance holding out hope of improving the range of high-frequency telegraphy and telephony, the very fact that many trunk circuits are already loaded with coils for the improvement of the existing system bids fair to interfere with the extension of the high-frequency system to these lines. To apply the high-frequency system to a line which is loaded for the existing system it becomes necessary to shunt the loading coils by condensers which shall act practically as a short circuit to the loading coils for the high-frequency currents and which shall act practically as an inappreciable shunt to them for the low-frequency telephone current. The cost and inconvenience of this would probably not offset the advantages to be gained from the increased effective number of circuits secured, but, however this may be, it is a fact that, so far as can be seen at present, *the high-frequency system will not be applied to more than one circuit on a pole line or in a cable,* and this one circuit could be left unloaded without great loss.

The reason that but one circuit on a pole line or in a cable, as these are at present constructed, can with advantage be multipled by the new high-frequency system is that the transposition of the wires on the existing pole lines and the twisting of the pairs of wires in the existing cables are adapted to give workable freedom from cross talk between the circuits with the existing frequency of current, the existing strength of current at the transmitter, and the existing sensitiveness of the receiver. When all these quantities are augmented, as they are in the high-frequency system, energy will flow from one circuit to another in the same cable or on the same pole line to an extent that will preclude the use of the same frequency of current for the transmission of different messages on different circuits in the same cable or on the same pole line.

In the latter half of this paper the new system has been treated more particularly in reference to its application to trunk lines, but the promise it holds out of a twenty-party sub-station telephone line with not only selective calling but selective or multiple speech transmission may to some, in itself, seem sufficient to justify the money that has been expended and the patient, unrequited human effort that has been freely given in bringing the new system to its present state of development, and to warrant the further effort and expenditures which will be necessary before it can yield its full service to society.

[17] The effect of dissipation of energy in the iron wire wrapping is to increase the effective or apparent resistance of the copper conductor. Thus in the Seeland-Samso-Jutland cable, which is about 20 nautical miles in length and is uniformly loaded by iron wire wrapping, the inductance is increased 868 per cent, and the apparent resistance to a current of 900 frequency is 5 per cent greater than to a direct current. What proportion of this increase in the effective resistance of the copper conductor is due to hysteresis loss in the iron wrapping is as yet undetermined. If it were wholly due to hysteresis, than it would be approximately 550 per cent at 100,000 frequency, but probably not more than one half of the increase in effective resistance of the copper conductor is due to this cause. The remainder is due to the unequal distribution or the imperfect penetration of the alternating current into the copper wire.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

A Convenient Method for Drawing Five-Centered Arches

By J. J. Klaber

LAY off on the semi-major axis OA a distance OB equal to the semi-minor axis OC. Divide the distance AB into five equal parts. Lay off seven of these divisions along OA from O to D. Draw OE and DE at 45 degrees. Lay off OF equal to twice OD. D, E, and F are the centers to be used in drawing the arch. This method, though not new, appears to be very little known. It s convenient in that it enables the position of the centers to be fixed by a very simple arithmetical calculaition, since

$OD = \frac{7}{5}(a-b)$

$OF = \frac{14}{5}(a-b)$

$OK = KD = KE = \frac{7}{10}(a-b)$, a and b being the semi-axes.

Although this formula is entirely empirical, its error is remarkably small. The exact degree of accuracy possible may be calculated as follows:

Let a = half span, b = rise (assumed value)

R_1 = radius of arc AG

R_2 = radius of arc GH

R_3 = radius of arc HC

e = error of closure

Then $R_1 = AD = a - \frac{7}{5}(a-b)$

$$R_2 = EG = ED + DG$$

$$= OD\frac{\sqrt{2}}{2} + R_1$$

$$= \frac{7}{10}(a-b)(\sqrt{2}-1) + a$$

$$R_3 = FH = FE + EH$$

$$= \sqrt{\left(\frac{OD}{2}\right)^2 + \left(\frac{3}{2}OD\right)^2} + R_2$$

$$= \frac{7}{10}(a-b)(\sqrt{10}+\sqrt{2}-2) + a$$

$$e = R_3 - (OF + b)$$

$$= \frac{7}{10}(a-b)(\sqrt{10}+\sqrt{2}-2) + a - \frac{14}{5}(a-b) - b$$

$$= \frac{7}{10}(a-b)(\sqrt{10}-\sqrt{2}-6+\frac{10}{7})$$

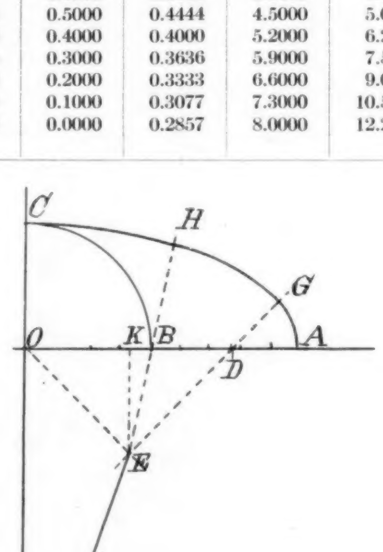
$$= 0.003544\,(a-b)$$

$$= \frac{a-b}{282} \text{ (approximately).}$$

The error therefore is always positive, and has a fixed relation to the difference of the axes. For small arches it is negligible; for larger ones it may easily be allowed for, its value being definitely known.

For arches approaching the circle, this method gives an arch whose radii, both at the springing and the crown, are greater than those of a true ellipse. When the arch is very flat the contrary is the case. In nearly all cases, however, the arch presents a good appearance and its convenience commends it for general use. The following table gives a comparison of this form of arch with the ellipse, for varying proportions, the rise being assumed equal to unity. In this table R_1 and R_3 are the radii of the five-centered arch, r_1 and r_2 the radii of curvature of the ellipse, for the points A and G, respectively:

a	$R_1 = a - \frac{7}{5}(a-1)$	$r_1 = \frac{1}{a}$	$R_3 = 1 + \frac{14}{5}(a-1)$	$r_2 = a^2$
1.00	1.0000	1.0000	1.0000	1.0000
1.25	0.9000	0.8000	1.7000	1.5625
1.50	0.8000	0.6667	2.4000	2.2500
1.75	0.7000	0.5714	3.1000	3.0625
2.00	0.6000	0.5000	3.8000	4.0000
2.25	0.5000	0.4444	4.5000	5.0625
2.50	0.4000	0.4000	5.2000	6.2500
2.75	0.3000	0.3636	5.9000	7.5625
3.00	0.2000	0.3333	6.6000	9.0000
3.25	0.1000	0.3077	7.3000	10.5625
3.50	0.0000	0.2857	8.0000	12.2500



This table indicates that when the rise is one seventh of the span, or less, this construction is impossible, and that when the rise is less than one sixth of the span, its use is not advisable. In practice, however, this will seldom be found to occur.

Mind and Matter

IT is not many years since a distinguished admiral, in opposing the grant of executive rank to naval engineers, observed that he had known a mere Lascar run engines very adequately, the presumption being that engineering was not a matter calling for the exercise of any intellectual faculties. We are rather inclined to the belief that the gallant admiral's view is widely shared by the public at large. Both the glory and the weakness of the engineer lies in the fact that his mental exercises afford occupation for hosts of mere manual laborers, with the result that the public in general, and their literary guides in particular unable to see the wood for the trees, are much disposed to deny that engineering is aught but a purely mechanical art. The extremists go even further, and refuse to rank the labors of the physicist and mathematician on the same intellectual plane as those of the poet and novelist. The argument, as we have heard it expressed by a distinguished Cambridge literary man, was to the effect that the work of each of the latter was unique of its kind, while if Dalton had not propounded the atomic theory, or Newton that of universal gravitation, it was probable that some other man of similar caliber would have done so sooner or later. If this contention were sound, the writer of the doggerel which occasionally disfigures a corner of some country newspaper, would rank intellectually above Archimedes and Clerk Maxwell.

The fact is, as pointed out by Mr. Campbell Swinton in a remarkably able and highly interesting address to the Röntgen Society of England, literary men have the ear of the world, and constitute the best organized and most successful mutual admiration society on record. The prominent position taken by the literary guild, and their often prejudicial influence on public opinion, lies in part, no doubt, in the fact that relatively little labor or application is required to enable a man to appreciate good literature. Everyone has views on literature, history, and sociology, and, with little or no training, can speak and argue on such subjects with absolute self-confidence.

A famous poet has declared that the noblest study of mankind is man; but the culture studies advocated by the literary guild are purely devoted to the interesting side of human endeavor, the personal deeds of this warrior or that statesman, who, after all, merely had their day and ceased to be. As a consequence the "humanities" have proved to be less a preparation for life than a form of distraction for leisure hours. Akin, therefore, to chess and golf, and like the latter pursuits, followed both by a small body of hard-working professionals and a very much larger mass of amateurs. No one, of course, advocates the abandonment of culture studies. Most of us sympathize with Herodotus when he avows as a reason for undertaking his history a reluctance to let fade into oblivion the great and admirable deeds of either the Greeks or the Barbarians. Nevertheless, the duties of life should take precedence of its distractions and general education should have a broader basis than that to which the literary guild would confine it.

The really effective force in molding humanity has been the scientific imagination. As Mr. Campbell Swinton pointed out, no historical character has affected the destinies of the race to more than an infinitesimal extent when his influence is compared with that of the unnamed savage who first had the intelligence to see the uses of fire, and the courage to attempt to control it. Some other unknown engineer first saw the possibilities of flint weapons, and once his individual intellect opened the path, the whole tribe of men were able to follow it. The extraordinary influence of scientific thought on the destiny of nations has of late years received a remarkable illustration by the excavations made at Crete. Here a whole civilization, in many respects of a very advanced type, appears to have been wiped out by invaders whose sole superiority lay in a better knowledge of the metallurgy of iron.

NEW BOOKS, ETC.

BRAZING AND SOLDERING. By James F. Hobart. New York: The Norman W. Henley Publishing Company, 1912. Price, 25 cents.

This is an excellent little handbook, which will undoubtedly serve to give many an amateur and practical man just the kind of information for which he is looking.

HOUSE WIRING. By Thomas W. Poppe. New York: The Norman W. Henley Publishing Company, 1912. Price, 50 cents.

This little treatise describes and illustrates up-to-date methods of installing electric light wiring. It is intended for the electrician, helper, and apprentice. It will aid in solving all wiring problems, and it contains nothing that conflicts with the rulings of the National Board of Fire Underwriters. Indeed, it contains just the information needed for the successful wiring of a building.

THE CHEMISTRY OF THE RADIO-ELEMENTS. By Frederick Soddy, F.R.S., Lecturer in Physical Chemistry and Radio-activity in the University of Glasgow. London: Longmans, Green & Co., 1911.

In this book Mr. Soddy has given us a very concise description of radioactivity, and has carefully summarized the present state of radio-active investigation. The book may be commended, coming as it does from one of the most distinguished investigators in this field.

KNOTS, SPLICES AND ROPE WORK. By A. Hyatt Verrill. New York: The Norman W. Henley Publishing Company, 1912. 150 cuts. Price, 60 cents.

The number of knots, ties, bends, hitches, splices and shortenings in use is almost unlimited, and they are most confusing and bewildering to the uninitiated. The most useful and ornamental as well as the most reliable are comparatively few in number, and in reality each new one learned leads readily to another. In this book the author has described them all in such a manner that their construction may be readily understood and mastered.

WOOD PULP AND ITS USES. By C. F. Cross, E. J. Bevan and R. W. Sindall. With the collaboration of W. N. Bacon. New York: D. Van Nostrand Company, 1911.

Without being a monograph or a textbook on the subject of wood pulp, the authors have given a general account of the evolution of the wood-pulp industry as typical of the age we live in, and as a very substantial contribution to its primary necessity.

TELEPHONY. By Samuel G. McMeen and Kempster B. Miller. Chicago: American School of Correspondence, 1912. 8vo.; 948 pp.; 671 illustrations. Price, $4.

Those who have had the opportunity of examining Mr. Miller's "American Telephone Practice" know him to be an authority on the subject of Telephony. The present volume, prepared in collaboration with Mr. McMeen, is a comprehensive and detailed exposition of the theory and practice of the telephone art and should prove a valuable textbook. The subject is covered in a thorough-going manner, and in a way that should prove interesting to laymen as well.

STUDIES IN THE PSYCHOLOGY OF INTEMPERANCE. By G. E. Partridge, Ph.D. New York: The Sturgis & Walton Company, 1912.

Dr. Partridge's book is written from the viewpoint that "since the causes of drinking are largely social, the cure and control must also be social." He pleads for a patient scientific study of the problem of intemperance before attempting to solve it, rather than to administer a hasty cure. Hence, he advocates experiments with animals in order to discover the effect of intoxicants on the lower organisms, and briefly reviews the investigations thus far made in the field, with the result that a marked influence on reproductive functions is shown to exist. His chapter on "Primitive Peoples' Drinking" is of more psychological value, for it shows that drinking among all primitive peoples was religious and social in its origin, and that "it was an act having significance." On the basis of the facts revealed in Sammelson's "History of Drink," the author considers the drinking of civilized nations, shows that national periodic intemperance occurs in evolutionary crises, and finds that "the intoxication motive that leads to the use of . . . intoxicants is best interpreted as one expression of a more general impulse, which is deep seated in the human race and is indeed fundamental to development." The deleterious effect of alcohol has always been of minor importance, not that it is negligible, but that it seems to have no place in man's evolution. But what is the place of intoxicants in evolution? According to Dr. Partridge, it is not determined "by discovering to what extent it may be a poison or a food." He finds the secret of its influence in the change caused in the intensity of consciousness, and not in any purely physiological effect. In considering the practical side of the problem—the saloon and the community and the disposition of the drunkard—the author is less helpful. His educational and preventive measures are those frequently advocated and so difficult to carry out because of society's inertia. But his book ought to be read by every worker in the cause of temperance; for it reveals the folly of regarding the desire for alcohol as a sin, requiring, therefore, no explanation, and the need of understanding the motives on which habits of intemperance are based.

MODERN RIDING AND HORSE EDUCATION. By Major Noel Birch, Royal Horse Artillery of Great Britain. New York: William R. Jenkins Company. 12mo.; 309 pp.; illustrated. Price, $2 net.

A GUIDE FOR THE STUDY OF ANIMALS. By a Committee from the Biology Round Table of the Chicago High Schools. Worrallo Whitney, Frederick C. Lucas, Harold B. Shinn, and Mabel E. Smallwood. New York: D. C. Heath & Co., 1911. 12mo.; 197 pp. Price, 75 cents.

THE LAST WORD. Being an Announcement of the Ultimate Generalization of Science and a Solution of Popular Problems in Religion and Philosophy. By James and Mary Baldwin, Ph.M. New York: Broadway Publishing Company. 12mo.; 105 pp. Price, $1.

PREVENTION OF RAILROAD ACCIDENTS OR SAFETY IN RAILROADING. A Heart to Heart Talk with Employes. By George Bradshaw. New York: The Norman W. Henley Publishing Company, 1912. 165 pp.; illustrated. Price, 50 cents.

THE WORK OF RAIN AND RIVERS. By T. G. Bonney, Sc. D., LL.D., F.R.S. New York: G. P. Putnam's Sons, 1912. 16mo.; 144 pp.; illustrated. Price, 40 cents net.

THE A B C OF THE DIFFERENTIAL CALCULUS. By William Dyson Wansbrough. New York: D. Van Nostrand Company, 1912. 8vo.; 148 pp. Price, $1.50 net.

CIVICS FOR FOREIGNERS. By Anna A. Plass. New York: D. C. Heath & Co., 1912. 12mo.; 187 pp.; illustrated.

EXPORTER'S ENCYCLOPEDIA. 1913 Edition. Containing full and authentic information relative to shipments for every country in the world. New York: Published by the Exporting Encyclopedia Company, 1,023 pp. Price, $7.50, including monthly corrections and the Exporter's Review for the calendar year.

The title of this book is sufficient recommendation to those who have use for information of the character contained therein. The Encyclopedia tells whether freight must be prepaid or otherwise; how many bills of lading are required and what statements must appear thereon; whether hazardous cargo is carried; what the lowest cost is for which a bill of lading will be issued to any port; whether "parcel receipts" are issued for small packages and the cost of same, etc. It also furnishes statistical data on population, products, etc., regarding each country treated. A very useful set of tables of weights and measures, etc., is also found in the early portion of the book.

TABLES OF THE WEIGHT OF AIR. Tabellen der Luftgewichte $\gamma^b{}_t$, der Druckaequivalente $\beta^b{}_t$ und der Gravitation g. Tables des poids de l'air $\gamma^b{}_t$, des equivalents barometriques $\beta^b{}_t$, et de la gravité g. Tables of the Weight of Air $\gamma^b{}_t$, of the Air-Pressure Equivalents $\beta^b{}_t$ and of the Gravity g. By Dr. S. Riefler. Pp. iv + 101. Berlin: Julius Springer, 1912. Price, bound, 6 marks.

In the introduction the author explains that in certain experiments which have been proceeding for a number of years in his laboratory, it was very important to correct the period of the pendulum of astronomical precision clocks for the influence of air pressure and temperature. Thus, for instance, if the value of the gravitational acceleration is constant, a change in the weight of one liter of air by a milligramme will introduce an error of one hundredth of a second per day in the time kept by the clock. The author has therefore compiled a very complete set of tables by means of which the necessary corrections can be made with little trouble. These will of course be useful not only for the author's particular work, but in connection with many other physical determinations. They are most excellently compiled and printed. The text is in English, French, and German.

MANUAL OF WIRELESS TELEGRAPHY AND TELEPHONY. By A. Frederick Collins. New York: John Wiley & Sons, 1913. 12mo.; 300 pp.; illustrated. Price, $1.50 net.

This manual first appeared some seven years ago, addressing itself to operators and to those desirous of becoming operators. This is a third edition, in which the later developments of wireless telegraphy and telephony are embodied.

THE RAILWAY CONQUESTS OF THE WORLD. By Frederick A. Talbot. Philadelphia: J. B. Lippincott Company, 1911. 12mo.; 340 pp. Price, $1.50 net.

The lucid style of Mr. Talbot has always appealed to the readers of the SCIENTIFIC AMERICAN, and he has presented an admirable picture of the struggles and successes of the venturesome railway engineers. The present volume is beautifully illustrated by inserted plates on coated paper. To-day the earth is girdled with some seven hundred thousand miles of railway. There are few countries in the world in which the locomotive has not made its appearance. The present volume has been written with the express purpose of telling, in a popular manner, the story of romance.

SOYER'S STANDARD COOKERY. A Complete Guide to the Art of Cooking Dainty, Varied and Economical Dishes for the Household. By Nicholas Soyer. New York: The Sturgis & Walton Company, 1913. Price, $1.50 net.

It is not often that a famous *chef* reveals the secrets of his art. That may be due to the circumstance that most good cooks are not writers, and that they are lacking in the gift of exposition. Soyer is an exception. His "Paper-bag Cookery" popularized an entirely new method of preparing food in a very simple and wholesome way. Paper bags have displaced many a pot and pan in the United States. In this "Standard Cookery" recipes for paper-bag cooking are included, but the book as a whole is devoted to the preparation of dishes by time-honored methods. The recipes given by Soyer are not those of the ordinary household cook, but the recipes of a great *chef*. This means that a great variety of methods is disclosed for preparing the standard meats, fish, and vegetables. Soyer's cook book is as far removed from the old volumes that have guided American housewives for decades as one can imagine, for the simple reason that there is a world of difference between the delectable art of preparing digestible and palatable dishes in the French way and the crude and extravagant American way. That Soyer takes an historical interest in his art is evidenced in the introduction to this book. Some excellent illustrations in color and in black and white show how various cold collations, cakes and confections should be served, how coffee should be made, and how joints and roasts should be cut. One feature of the book that will commend itself to Americans are the recipes that show how good and wholesome dishes can be made of the many cereals now on the market.

AUTOMOBILTECHNISCHES HANDBUCH. Herausgegeben im Auftrage der Automobiltechnischen Gesellschaft E. V. von Dr. Ernst Valentin unter Mitwirkung von E. Aders, M. H. Bauer, F. Klinkenberg, F. Meitner, J. Menzel, E. Schaefer, E. Schimek, K. Schroeder, Dr. F. Warschauer, O. Winkler. Siebente Auflage. Berlin W.: Verlag von M. Krayn, 1913.

This is an excellent engineering handbook for the designer of automobiles. It follows the lines of such well-known engineering handbooks as Huette in German, Kent and Haswell in this country.

DEER BREEDING FOR FINE HEADS. With Descriptions of Many Varieties and Cross-breeds. By Walter Winans, F.Z.S. London: Rowland Ward, Limited, 1913. 4vo.; 105 pp.; 32 illustrations. Price, 12s 6d net.

ELECTRIC BELLS, INDICATORS, AND AERIAL LINES. By Umberto Zeda. Translated from the Italian and Revised by S. R. Bottone. Philadelphia: David McKay, 1913. 12mo.; 120 pp.; 109 illustrations.

STORIES OF INDUSTRY. Vol. I. By A. Chase and E. Clow. New York: Educational Publishing Company. 12 mo.; 172 pp.; illustrated. Price, 60 cents net.

DIAGNOSIS FROM THE SPINE. By Prof. B. H. Jones. Pittsburgh, Pa.: B. H. Jones. 8vo.; 255 pp.; illustrated.

THE NATURALIST IN NICARAGUA. By Thomas Belt. New York: E. P. Dutton & Co. 16mo.; 306 pp.; illustrated. Price, 35 cents.

A DICTIONARY OF DATES. Brought down to the Present Day. By Eric F. Smith. New York: E. P. Dutton & Co. 16mo.; 302 pp. Price, 35 cents.

FRENCH MEDIAEVAL ROMANCES. New York: E. P. Dutton & Co. 16mo.; 217 pp. Price, 35 cents.

LEGENDS OF CHARLEMAGNE. By Thomas Bulfinch. New York: E. P. Dutton & Co. 12mo.; 240 pp. Price, 35 cents.

GROWING CROPS AND PLANTS BY ELECTRICITY. By E. C. Dudgeon. London; S. Rentell & Co., Ltd. 8vo.; 36 pp.; 12 illustrations. Price, 40 cents.

POPULAR MECHANICS YEAR BOOK FOR 1913. Vol. IX. Chicago: Popular Mechanics. 8vo.; 214 pp.; illustrated. Price, 50 cents.

PROCESSES OF FLOUR MANUFACTURE. By Percy A. Amos. New York: Longmans, Green and Co. 8vo.; 280 pp.; illustrated. Price, $1.50 net.

MAN. A History of the Human Body. By Arthur Keith, M.D., LL.D. New York: Henry Holt and Company. 16mo.; 256 pp. Price, 50 cents net.

HYGIENE FOR THE WORKER. By William H. Tolman, Ph.D., and Adelaide Wood Guthrie. Edited by C. Ward Crampton, M.D. New York: American Book Company, 1912. 12mo.; 231 pp.; illustrated.

Without confusing the reader with any talk of anatomy, "Hygiene for the Worker" places before him the accepted regimen of right living—bodily cleanliness, sensible eating and drinking, moderate exercise, and sufficient rest. It is a little book of instruction that should be in every home, for its simple statement of hygienic facts, and the charm of its primer-like line drawings, would go far toward creating national habits of cleanliness that would soon affect mortality statistics, and raise the plane of individual health, vigor and happiness.

LABORATORY STUDIES IN CHEMISTRY. By Robert H. Bradbury, A.M., Ph.D. New York: D. Appleton & Co., 1912. 8vo.; 129 pp.; illustrated.

Teachers will appreciate a laboratory manual which covers the syllabi they have to consider in preparing students for college. Each of the exercises can be finished within ninety minutes.

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Table of Contents